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Final

Work Plan for In Situ Chemical Oxidation Pilot Study at the Solvent Disposal Pit Area of Site 1

**Allegany Ballistics Laboratory
Rocket Center, West Virginia**

Contract Task Order 170

April 2005

Prepared for

**Department of the Navy
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Prepared by



CH2MHILL

Herndon, Virginia

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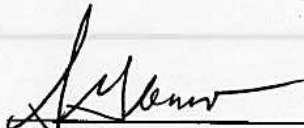
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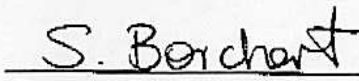
Approved by:


Steve Glennie
Activity Manager

Date:

4/21/05

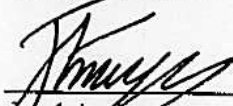
Approved by:


Susanne Borchert
Senior Reviewer

Date:

04/21/05

Approved by:


José A. Amaya
Project Manager

Date:

4/21/2005

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Acronyms and Abbreviations

ABL	Allegany Ballistics Laboratory
AOC	Area of Concern
bgs	below ground surface
COPC	constituents of potential concern
1,2-DCE	1,2-dichloroethene
DNAPL	dense non-aqueous phase liquid
DOC	dissolved organic carbon
DPT	direct push technology
FSP	Field Sampling Plan
gpm	gallons per minute
HASP	Health and Safety Plan
IDW	investigation-derived waste
IDWMP	Investigation-Derived Waste Management Plan
ISCO	in situ chemical oxidation
MC	methylene chloride
NAPL	nonaqueous phase liquid
OPTV	optical/acoustical televiewer
PPE	personal protective equipment
PRAP	Proposed Remedial Action Plan
QAPP	Quality Assurance Project Plan
RI	Remedial Investigation
SOP	Standard Operation Procedure
SWMU	Solid Waste Management Unit
TAL	target analyte list
1,1,1-TCA	1,1,1-trichloroethane
TCE	trichloroethene
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TDS	total dissolved solids
TOC	Total Organic Carbon
TOD	Total Oxidant Demand
TSS	total suspended solids
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound

SECTION 1

Introduction

This Work Plan outlines the design basis for conducting in situ chemical oxidation (ISCO) at the Solvent Pit Area of Site 1, at Allegany Ballistics Laboratory (ABL) in Rocket Center, West Virginia. The purpose of the pilot studies is to determine if in situ source treatment using current remediation technologies is effective or feasible in reducing contaminant mass in the alluvial and bedrock aquifers at Site 1. The long-term goal for the pilot studies is to identify a technology that will cost-effectively reduce contaminant mass in the areas of Site 1 groundwater that may contain dense non-aqueous phase liquids (DNAPLs) with the intent to expedite remediation and/or reduce life-cycle cost of the current pump and treat system.

This work plan is an addendum to the *Final Work Plan for the Phase III Solid Waste Management Unit (SWMU) and Areas of Concern (AOC) Investigation* (CH2M HILL, 2002a), hereafter referred to as the Phase III SWMU/AOC Work Plan. Other documents referenced throughout this document are listed in Section 6. This Work Plan makes reference to background and procedural information in the aforementioned document, as appropriate, and presents only new information that is specific to the in situ remedial activities or procedural information that varies from that documented in the aforementioned documents.

1.1 Background

Site 1 is an 11-acre area that consists of several disposal units, including an active 8-acre, fenced burning ground for reactive wastes including propellants and explosive wastes, three inactive disposal pits for spent solvents and acids, a former drum storage area for drums containing hazardous wastes, a former landfill for ash, and a former burning area for inert substances. The three disposal pits have been backfilled, all drums have been removed from the drum storage area, and both the ash landfill and the inert burning ground are overgrown with vegetation.

Site 1 has been part of a number of investigations conducted at ABL. Information gathered during the Remedial Investigation (RI) and Focused RI (CH2M HILL, 1996a and 1995) indicated that volatile organic compounds (VOCs; specifically trichloroethene [TCE], 1,2-dichloroethene [1,2-DCE], 1,1,1-trichloroethane [1,1,1-TCA], methylene chloride [MC], and acetone) were the most widespread constituents of potential concern (COPCs) detected at Site 1 in soil, alluvial and bedrock groundwater, surface water, and sediment. Groundwater at Site 1 was further evaluated as documented in the Focused RI (CH2M HILL, 1995) and the Focused Feasibility Study (CH2M HILL, 1996c).

The Navy issued a Proposed Remedial Action Plan (PRAP) for groundwater, surface water, and sediment in October 1996 and the associated ROD was signed in May 1997. The selected remedy for Site 1 groundwater and the surface water and sediment of the North Branch Potomac River adjacent to Site 1 was site-wide alluvial and bedrock groundwater

containment (i.e., capture and removal) with subsequent onsite treatment and discharge of treated water to the river.

Construction of a groundwater treatment facility for the extracted groundwater at Site 1 began in September 1997. The treatment plant began continuous operation in September 1998 and has treated an average of more than 100 gallons per minute (gpm) of groundwater extracted from Site 1 since that time. Currently, treated groundwater is utilized by the ABL boiler plant, with excess water being discharged to the river. Discharge limits for the treatment plant include discharge rates, VOCs, and metals.

1.2 Scope and Objective

The scope of work presented in this work plan encompasses the design and implementation of the *in situ* chemical oxidation (ISCO) pilot study to treat groundwater in the alluvial and bedrock aquifers at Site 1.

ISCO is the technology chosen for the pilot study. The oxidants being used differ in the two aquifers being treated: sodium persulfate ($\text{Na}_2\text{S}_2\text{O}_8$, and a catalyst) will be used in the alluvial groundwater and potassium permanganate (KMnO_4) will be applied to the bedrock aquifer. The objective of the pilot study is to determine the effectiveness of these technologies in reducing contamination mass at the site.

The contaminants of concern (COCs) in the site alluvial and bedrock groundwater are chlorinated volatile organic compounds (VOCs).

1.3 Work Plan Organization

This work plan is divided into the following sections:

Section 2 – Analysis of Site Characterization Results. This section discusses the results of the characterization activities of the pilot study area.

Section 3 – In situ Chemical Oxidation Implementation. This section describes the field procedures that will be followed to install the injection and monitoring wells and to implement the ISCO.

Section 4 – Project Reporting. This section describes how the results of the ISCO implementation will be reported.

Section 5 – Project Schedule. This section provides an estimated schedule for the ISCO implementation.

Section 6 – References. This section lists references cited in the work plan.

SECTION 2

Analysis of Site Characterization Results

Site characterization activities were conducted in accordance with the *Final Work Plan for the Characterization Phase of Pilot Studies at the Solvent Disposal Area of Site 1* (CH2M HILL, 2004b.) The activities conducted in the characterization phase included determining the presence dense non-aqueous phase liquid (DNAPL); bench scale testing; installing monitoring wells and injection wells; a downhole geophysical survey of the bedrock; and collecting and analyzing soil, bedrock, and groundwater samples.

The activities were conducted in the following sequence:

1. Distribution of existing free phase DNAPL was evaluated in the alluvial aquifer by installing and extracting a reactive FLUTe™ NAPL liner using the direct-push technology (DPT).
2. Using DPT, soil samples were collected in the alluvial formation for laboratory analyses at the top, middle, and bottom of the saturated zone.
3. Alluvial wells were drilled to the top of the bedrock using air rotary techniques, then cased using stainless steel, and developed.
4. The open borehole bedrock wells were drilled using the air rotary method. One bedrock sample was collected during drilling.
5. Soil samples were collected for bench scale testing.
6. Groundwater samples were collected from the alluvial aquifer for bench scale testing and laboratory analyses.
7. Distribution of free phase DNAPL was evaluated in the bedrock boreholes by placing a FLUTe™ liner into the holes.
8. Geophysical logging was conducted in the newly installed open borehole bedrock wells.
9. Groundwater samples were collected in the newly installed bedrock wells from target zones determined by the DNAPL evaluation and geophysical logs.

2.1 FLUTe™ NAPL Liner Results

The FLUTe™ technology was used to locate potential layers, filled fractures, and globules of DNAPL in the alluvial and bedrock subsurface. The FLUTe™ technology utilizes a liner with a reactive coating, which was everted into a punched hole for the alluvial subsurface and a drilled hole for the bedrock. The reactive coating was in contact with the sides of the borehole and reacted with DNAPL in contact with the reactive coated liner to produce a stain on the reactive coating. The liner was then inverted to remove it from the subsurface. Removal of the liner by inversion prevented contact with other surfaces. The stains on the

liners were evaluated to determine the vertical distribution of free phase DNAPL in the boreholes.

2.1.1 Alluvial FLUTe™ Results

A DPT rig was used to install the liner in the alluvial formation. Reactive liners were installed via the interior of push rods at 4 locations (1IW02, 1IW01, 1MW01, and 1IW04). The liners were installed from the ground surface to between 16.5 ft and 21.8 ft below ground surface (bgs). The liners did not indicate the presence of DNAPL in the alluvial formation. The DPT was not able to advance the liners into the coble zone present at the base of the alluvial aquifer. It is possible that DNAPL is present in that permeable zone.

2.1.2 Bedrock FLUTe™ Results

FLUTe™ reactive liners were installed into three newly installed bedrock wells (1IW04, 1MW02, and 1MW03). The reactive liners were everted into the open bedrock boreholes by filling the liners with water until the bottom of the borehole was reached, approximately 90 ft bgs. The hydraulic pressure inside of the liner facilitated contact between the liner and the sides of the bedrock hole. The liners were removed by pulling a tether attached to the bottom, thereby inverting the liner, and expelling the water which was treated at the ABL groundwater treatment plant. Table 1 shows depths and staining descriptions from each borehole:

TABLE 1
FLUTe™ DNAPL Liner Results - Bedrock Formation Characterization
Work Plan for In Situ Chemical Oxidation Pilot Study at the Solvent Disposal Pit Area of Site 1

Well ID	Depth (feet bgs)	Bedrock FLUTe™ NAPL Description
1IW04	NA	No staining was encountered.
1MW02	69.4	Three 0.5" to 1" globules from possible fracture.
	71.7	Several 0.5" to 2" diameter stains indicating a possible partially opened angled fracture. The fracture is not saturated with free product.
	83.5	Several dime sized globules. The globules possibly indicate that DNAPL was migrating down the borehole wall from a fracture above.
	87.9-88.5	Several 1" to 2" diameter staining from possible fracture.
1MW03	89-91.2	Several 1" to 3" diameter staining. DNAPL possibly migrating down bedrock wall from a fracture above.
	32.73	Several 1" diameter staining at the base of the outer casing, possibly from a fracture behind the casing
	84.7-90.2	Abundant 1" to 5" diameter vertical staining. Possible vertical fracture. Fracture is not saturated with DNAPL.

2.2 Bench Scale Test Results and Analysis

A bench scale test was conducted to determine the site-specific quantities of oxidants required to treat the contaminant mass. The test was also used to determine the amount of natural organic matter in the subsurface which will use the oxidants, and to predict geochemical shifts in dissolved metal concentrations following oxidant addition. Bench scale test descriptions and results are provided in Appendix A.

A secondary result of ISCO (especially using permanganates) is mobilizing inorganics that were sorbed to natural organic matter due to oxidation of this matter. It is hypothesized that the redox-sensitive and exchangeable sorbed inorganics are partially displaced while high oxidation concentrations persist. Once the oxidant is consumed, groundwater conditions return to their pre-injection state, and these processes are reversed, thereby immobilizing the inorganics. To help assess the potential magnitude of metals being mobilized during the pilot study, geochemical analyses were conducted for the alluvial and bedrock aquifers during the characterization phase.

Alluvial aquifer soil and groundwater samples were collected according to the *Final Work Plan for the Characterization Phase at the Solvent Disposal Pit area of Site 1 (CH2M HILL, 2004b)*. Field parameters were collected and are presented in Table 2. Groundwater samples were sent to a lab for total and dissolved inorganic analyses. The results (presented in Tables 3 and 4 and 5) show that all total and dissolved inorganics fall below the discharge limits with the exception of beryllium at location 1MW01, which was flagged B (indicating that a blank sample also contained beryllium). The value only slightly exceeded the discharge limit, for the water treatment plant; however, the average beryllium concentration of the four alluvial wells was below the discharge limit for the water treatment plant outfall.

Soil and groundwater was submitted to a treatment lab for bench scale metal leaching tests. A description of the bench scale study is included in Appendix A. The bench scale metal leaching test compared initial total inorganic analyses with those after the sample had been treated with sodium persulfate and had been allowed to react for 3 days. Initial chromium detected in the soil and groundwater mixed sample at 1.98 mg/L was above the discharge limits, however, the value decreased to below the detection limit of 0.01 mg/L in groundwater after the persulfate treatment. The soil matrix (chromium adsorbed to manganese dioxide or iron oxyhydroxyls) contributed primarily to the initial value rather than the dissolved chromium. Manganese and nickel were also below their respective analytical detection limits in the post-treatment samples, and were well below discharge limits for the entire test. This suggests that not only are the total and dissolved inorganic concentrations in the natural environment low, but that treatment in the alluvial aquifer with sodium persulfate will not mobilize inorganics above discharge limits.

A crushed bedrock sample was submitted for inorganic analyses, and several groundwater samples from bedrock boreholes were submitted for inorganic analyses. Based on these results and the groundwater condition (pH, temperature, ORP, etc.), the potential for potassium permanganate to mobilize inorganics is considered low, as long as the dosing of the permanganate is appropriate for the organics targeted (i.e., not overdosed). The high iron and, to a lesser degree, manganese present in the limestone bedrock matrix will sorb chromium and arsenic. Other inorganics are very low in concentration in the crushed

bedrock, as expected for limestone, and are not expected to pose a potential discharge exceedance.

A secondary result of ISCO using permanganate that is sometimes observed is mobilization of selected inorganics (Fe, Ni, and Cr). These inorganics may be displaced while high permanganate concentrations persist. Once permanganate concentrations decrease (weeks to months) groundwater conditions are expected to return to their pre-injection state. In order to predict the amounts of inorganics that could be mobilized from the bedrock (where permanganate is planned for injection during the pilot study), a rock core sample was crushed and analyzed for inorganics (for results see Attachment 1). Potassium and manganese may also increase because they are part of the oxidant and are naturally occurring in the bedrock. Of the five inorganics that may be mobilized (Fe, Ni, Cr, K, and Mn), iron and potassium do not have discharge limits from the ABL Groundwater Treatment Plant. Table 6 presents the worst case scenario for metals increases at extraction well 1EW29, which is the bedrock extraction well that is expected to be most impacted by the pilot study. Table 6 also shows the resulting influent concentrations of these metals to the groundwater treatment plant, under this worst-case scenario. The worst case metals influent values in Table 6 do not exceed the discharge limits for the groundwater treatment plant.

Table 6 – Metals Potentially Mobilized During Pilot Test

	Fe, Ni, Cr
Worst case scenario at 1EW29	Ni = 16,000 µg/L Mn = 6,000 µg/L Cr = 1,500 µg/L
Worst case scenario influent to GWTP	Ni = 416 µg/L Mn = 155 µg/L Cr = 46 µg/L

To mitigate overdosing in the fractured bedrock environment, relatively low KMnO₄ concentrations and large volume of fluids will be used during injection.

In the alluvial aquifer, oxidant injection will primarily affect manganese concentrations. Assuming the post-treatment manganese concentration from the bench scale study (203 µg/L) will be in extracted groundwater in alluvial extraction wells 1EW17, 1EW18, and 1EW19 (1.3% contribution of overall flow) and in the bedrock extraction well 1EW29 (3.5% contribution of overall flow), the dilution from all other wells contributing to the influent metals concentrations of the GWTP will cause dissolved manganese levels to remain below the discharge requirements.

2.3 Downhole Geophysical Characterization

A geophysical investigation was conducted in the three newly installed open bedrock boreholes for fluid temperature, fluid conductivity, optical televiewer (OPTV), acoustical televiewer, and caliper (borehole diameter). The results are provided in Appendix B for bedrock wells 1MW02, 1MW03, and 1IW04, respectively. In all open boreholes the

temperature/conductivity data were collected first, followed by the OPTV, the acoustical televiewer, and finally the caliper test.

- **1MW02** – Relatively fewer fractures were observed in 1MW02 than 1IW04 and 1MW03. Fractures generally dipped to the east at angles ranging from 4.4 to 84.7 degrees with the average dip at 58.7 degrees. The largest fracture zone in the borehole was found at 43.0-43.5 feet. A change in the temperature log at this interval suggests that this zone may be water producing. A large inflection in the fluid conductivity measurement was noted at 57.5 feet and the OPTV showed several partial open fractures at this depth. No other significant fractures were located below 57.5 feet.
- **1MW03** – Bedrock observed in borehole 1MW03 appeared to be more fractured with water producing zones than 1MW02 and 1IW04. Fractures were generally more evenly spaced. Above 65 feet, fractures generally dipped north and east and below 65 feet they generally dipped to the west. Several partially open fractures were seen on the OPTV and acoustical televiewer log extending from 32.1 (immediately below the casing) to 44.0 feet bgs. The widest open fracture found in the boreholes was noted at 1MW03 at approximately 52.9 – 53.6 feet. Several partially open fractures were identified on the OPTV and ATV within 54.3 – 58.2 feet, 60.0-62.8 feet, and 66.0-67.8 feet. Temperature and conductivity inflections were noted over these intervals. Conductivity increased abruptly from approximately 560 $\mu\text{S}/\text{cm}$ at 67.5 ft bgs to 577 $\mu\text{S}/\text{cm}$ at 72 ft bgs. One or more of these fractures may be fluid entry-exit points. Several mostly mineralized, fractures were identified throughout the remaining length of the borehole with minor inflections noted on the temperature and conductivity logs but none of these features appear to be significant water bearing zones.
- **1IW04** – The televiewer log interpretation concluded the whole length of the borehole consisted of partially open fractured bedrock. The fractures above 65 feet generally dipped to the north and fractures below 65 feet generally dipped to the west. Two significant open fractures were identified: a continuous open fracture at approximately 39.8 feet bgs and a wide open fracture at 74.5 feet bgs. A significantly weathered fracture zone was identified at 57.0-58.0 feet which appears to be a significant water producing zone because of inflections in the temperature and conductivity logs at this interval. An inflection in the conductivity log also appears at 74.5' (approximate depth of the wide open fracture) which indicates a possible water producing aperture.

2.4 Soil and Groundwater Sample Results

Tables 2 through 5 presents the analytical results for soil, alluvial and bedrock groundwater samples collected during site characterization. Samples were collected in accordance with the Field Sampling Plan (FSP) and Quality Assurance Project Plan (QAPP) addenda in the Site 1 Characterization Phase Work Plan (CH2M HILL, 2004b). Figures 1 and 2 show the locations of the wells sampled in the alluvium and bedrock aquifers.

Water level measurements were taken in the newly installed alluvial and bedrock wells during the February 22, 2005 sampling event. The groundwater elevations indicate the direction of groundwater flow in the alluvial and bedrock formation is generally to the north-northwest toward the North Branch Potomac River which agrees with the

potentiometric surface description in the 1996 Remedial Investigation Report (CH2M HILL, 1996a).

2.4.1 Soil Analytical Results

Table 2 presents the laboratory analytical results for soil samples collected in the solvent pit area of Site 1 using direct push technology (DPT). Twelve subsurface soil samples were collected in 4 alluvial aquifer locations (1IW01, 1IW02 1IW03, and 1MW01; see Figure 1) from the top, middle, and bottom of the saturated zone. Samples were analyzed for TCL VOCs, TAL metals, nitrate, nitrite, sulfate and total organic carbon (TOC).

Several VOCs were detected at each location and at each depth. The highest VOC concentrations were detected at station 1IW01, including the highest concentration for TCE: 180,000 µg/kg at 16-17 ft bgs.

2.4.2 Alluvial Aquifer Analytical Results

Three injection wells and 1 monitoring well were sampled in the alluvial aquifer on February 22, 2005, using a low-flow submersible pump positioned in the middle of the screen. Water quality parameters (temperature, pH, specific conductivity, DO, and ORP, listed in Table 3) were measured during purging of the wells using a flow through cell. Samples were analyzed for TCL VOCs, TAL total and dissolved metals, cyanide, sulfate, nitrate, nitrite, chloride, TOC, DOC, ortho-phosphate, hardness, TSS, TDS, and alkalinity (see Table 4).

Figure 3 depicts TCE concentrations detected in groundwater. TCE was detected in all four alluvial wells at concentrations ranging from 39,000 µg/L to 180,000 µg/L. The highest VOC concentrations were detected in 1MW01 which is located approximately 15 feet north of the estimated solvent pit area. These concentrations are indicative of residual DNAPL.

2.4.3 Bedrock Aquifer Analytical Results

Samples were collected in the open boreholes at various depths to target specific zones, which were selected based on the DNAPL characterization using the FLUTe™ liners and downhole geophysical results. A low-flow submersible pump was used to extract the groundwater for collection. Sample analyses were the same as the alluvial aquifer. Table 5 presents the analytical results of the bedrock aquifer samples.

Figure 4 depicts TCE concentrations detected at each target zone. VOCs were detected at all three wells at each depth. The highest VOC concentrations were detected at monitoring well location 1MW02, including the TCE concentration (110,000 µg/L) at 86.71 ft bgs.

In Situ Chemical Oxidation Implementation

3.1 Technology Description

ISCO is the technology chosen for the pilot study, due to its expected efficiency in reducing the VOC mass in the subsurface. Several oxidants can be injected (permanganates, sodium persulfate, ozone, hydrogen peroxide), however, based on the site conditions (COC concentrations, types of chlorinated solvents, type of aquifer), two different oxidants were selected for the alluvial and bedrock aquifers. These are described below.

3.1.1 Sodium Persulfate with Steam as a Catalyst

To chemically destruct the site contaminants, sodium persulfate ($\text{Na}_2\text{S}_2\text{O}_8$) will be injected within the alluvial aquifer. The goal is to completely oxidize the chlorinated VOCs to carbon dioxide and water. When mixed with water, sodium persulfate disassociates to form sodium and persulfate ions. Persulfate reacts with chlorinated VOCs to produce carbon dioxide, water, chloride ions, and sodium sulfate.

Activation of persulfate, making it more reactive, is accomplished by heat or co-injection of metals. Steam is an effective heat source for the activation and was chosen for the application at Site 1 as it is readily available at the facility.

3.1.2 Field Application of $\text{Na}_2\text{S}_2\text{O}_8$

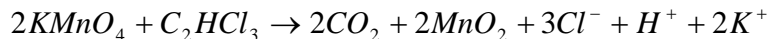
The use of $\text{Na}_2\text{S}_2\text{O}_8$ to oxidize chlorinated VOCs has been increasing in over the last 2 years. It is less well documented than the use of other oxidants, however, it has shown advantages over the other oxidants, such as lower chemical cost and the ability to treat a wider variety of chlorinated solvents. Sodium persulfate is commercially available as a crystalline solid, with an aqueous solubility of up to 73 percent, depending on the temperature of the water. Injecting a sodium persulfate solution treats a groundwater plume in situ.

3.1.3 Potassium Permanganate

The bedrock pilot study area containing the chlorinated VOCs will be treated with potassium permanganate (KMnO_4) as an oxidant. Potassium permanganate was selected for ISCO in the fractured bedrock based on cost and , ease of implementation, the fact that there is no need for catalyst, as well as reduced handling risks when compared to oxidants such as hydrogen peroxide.

3.1.4 Chemistry of In Situ Chemical Oxidation with KMnO_4

Potassium permanganate, a strong oxidizing agent, is reduced to manganese dioxide and potassium ion while oxidizing the chlorinated VOCs to carbon dioxide and water. Balanced oxidation-reduction reactions of KMnO_4 with the TCE at the site can be written as follows:



Potassium permanganate oxidizes the degradation byproducts of TCE including cis-1,2-DCE and vinyl chloride, but has shown only limited effects on chlorinated ethanes. The resultant manganese oxide (MnO_2) is a natural mineral and produces a solid precipitate in the soil or bedrock.

3.1.5 Field Application of KMnO_4

Oxidation of chlorinated VOCs by potassium permanganate is well documented and has been studied extensively in laboratory and bench scale applications. Potassium permanganate is commercially available as a crystalline solid, with an aqueous solubility of up to 7 percent, depending on the temperature of the water. Injecting a potassium permanganate solution treats a groundwater plume in situ.

3.2 Well Installation

The pilot study will include the wells installed during the site characterization phase and additional wells proposed in this work plan. The additional injection and monitoring wells proposed for the alluvial and bedrock aquifers will be installed using casing advancement air rotary drilling techniques. The casing advancement drilling technique is expected to reduce the potential for DNAPLs to migrate vertically from the alluvial aquifer into the bedrock aquifer. The soil and rock cuttings will be handled as investigation-derived waste (IDW) and placed in a roll-off bin for further characterization, to be properly disposed. Drilling fluids, from decontamination and well development, will be conveyed to a 5,000 gallon Baker tank and transported later to the on-site treatment plant. Appendix F presents the IDW management plan associated with this project.

3.2.1 Alluvial Wells

Four additional injection wells and 7 additional monitoring wells will be installed for the pilot study in the alluvial aquifer at the solvent pit area as shown in Figure 1. The wells will be installed using casing advancement drilling techniques, and will extend to the top of bedrock located at approximately 30 feet bgs. The alluvial monitoring wells will be constructed with 2-inch diameter, stainless steel, with a 10 or 15 feet, 0.01" slotted screen and injection wells will be constructed with 2-inch diameter stainless steel with threaded connections. Stainless steel is required since steam will be used as a catalyst. A shallow and deep alluvial well will be installed adjacent to each other down gradient of the solvent pit area (Figure 1). The shallow well (1MW11s) will be screened from 12 to 22 ft bgs and the deep well (1MAW11D) will be screened from 22 to 30 ft bgs. The shallow and deep wells will be installed to capture the expected downward flow in the Downgradient region.

3.2.2 Bedrock Wells

Two additional monitoring wells will be installed for the pilot study in the bedrock as shown in Figure 2. The bedrock wells will extend approximately 60 feet into the saturated bedrock, with a final depth of 90 feet bgs. A 6-inch diameter borehole will be advanced, using casing advancement techniques, through the unconsolidated overburden to approximately 3 to 5 feet into the top of bedrock. The remainder of the well boring will be 4 inches in diameter and drilled to 90 feet bgs.

3.2.3 Well Abandonment

Following completion of the pilot study, the alluvial and bedrock injection and monitoring wells installed for this study will be abandoned in accordance with applicable WVDEP regulations.

3.3 ISCO Implementation

The focus of the Site 1 disposal pit pilot study is the groundwater located in the bedrock and alluvial aquifers around the westernmost disposal pit. Groundwater in this area exhibits high TCE concentrations, indicative of residual DNAPL.

3.3.1 Dosing Parameters and Target Remediation Zone for NaSO_4

Sodium persulfate will be injected within the alluvial aquifer (Figure 1). For the injection event, approximately 26,000 pounds of sodium persulfate will be injected at a five weight-percent solution by injecting similar amounts in each injection well. Approximately seven injection points will be needed to treat the targeted area, assuming a 20-foot radius of influence around each injection point. Steam, used as a heat catalyst, will be injected after sodium persulfate has been injected into the injection wells. It is expected that steam will be injected in each well sequentially over a period similar to the injection period (expected to be 4 days). The sodium persulfate will treat a 150 x 90 ft area with a 13 ft thick zone.

The site dosage was estimated based on the total oxidant demand (which includes oxidant for natural organic matter that also reacts with the oxidant) and the treatment zone COC mass as determined by the characterization data and bench scale testing.

A possible secondary effect of the sodium persulfate injection is a decrease in pH and thus an increase in the concentrations of dissolved inorganics. To mitigate this, buffers will co-injected with the persulfate.

3.3.2 Dosing Parameters and Target Remediation Zone for KMnO_4

The area targeted for remediation in the bedrock, as shown on Figure 2, is approximately 3,600 ft² and extends from the top of bedrock at 30 feet bgs to a depth of 90 feet bgs. This translates into an approximate volume of 27,000 gallons of VOC-impacted groundwater containing a total of approximately 1 pound of chlorinated VOCs. An approximately 3 weight-percent solution of potassium permanganate will be injected within the bedrock aquifer. Approximately 970,000 gallons of solution will be injected.

Oxidant demand factors and site dosages were estimated based on previous results at similar sites. Dosage amounts at this site are also based on the treatment zone COC mass. The injection will be done using one injection point within the solvent disposal pit.

3.4 Groundwater Monitoring

3.4.1 Post-Injection Concentrations

The ISCO reactions will be closely monitored for their in situ effects as well as impact on the groundwater reaching the treatment plant. Concentration of VOCs within the pilot study

treatment areas are expected to decrease rapidly during the ISCO applications due to oxidation of VOCs in the alluvium and bedrock, thus decreasing the VOC load being delivered to the GWTP. During the oxidation process, carbon dioxide (CO₂), chloride ions, and other dissolved ions are produced as well as manganese dioxide (when injecting potassium permanganate) and sulfate ions (when injecting sodium persulfate). While manganese dioxide is immobile and readily precipitates out of solution, some sulfate ions are likely to arrive at the treatment plant in the form of sulfate. Monitoring data will be evaluated, if two consecutive exceedances are observed the affected wells resulting in these exceedances will be shut down. A plan to address this exceedance will then be developed.

In rare cases, it has been documented that solvents are initially be desorbed from the soil/rock matrix in the pilot study areas during oxidation due to the concentration gradients created (between the solvents sorbed to soil/rock and those in the dissolved phase). If this occurs, there would likely be a temporary increase in the VOC concentration in the groundwater extracted from the wells within the treatment area. The likely affected extraction wells would be 1EW17, 1EW18, and 1EW19 in the alluvial aquifer and 1EW29 in the bedrock aquifer. Under a worst case scenario, total VOCs would increase to 180,000 µg/L in the alluvial extraction wells 1EW17, 1EW18, and 1EW19 (which collectively contribute 1.3% of overall flow), and increase to 110,000 µg/L in the bedrock extraction well 1EW29 (which contributes 3.5% of the overall flow). Taking into account the dilution from all other wells the total VOCs concentration entering the stripper would increase to 7,723 µg/L (as opposed to 4,100 µg/L under typical flow conditions). See Table 8 for the estimated VOC post injection concentration. Based on manufacturer-supplied performance specifications, the air stripper is expected to be able to treat this potential increased VOC concentration such that the discharge requirements continue to be met. The air stripper has the capacity to treat water such that the effluent concentration is less than 20 µg/L TCE (the monthly limit is 26 µg/L) at a flow rate of 300 gpm and an influent concentration of 15,000 µg/L TCE. Additionally, the potential increase in VOC concentrations is not expected to cause an exceedance of the air emission limit (10,000 pounds per year).

3.4.2 Groundwater Sampling

Performance monitoring will be conducted through three event samplings from 8 alluvial monitoring wells and 4 bedrock monitoring wells. Monitoring will be conducted prior to injection, 3 weeks after injection, and will continue with a sampling event approximately 6 weeks, 3 months and 5 months after injection.

The objectives of the monitoring events are to document mass removal. The sampling will also be used to document any rebound from residual mass and determine if mass is migrating back into the area from upgradient areas. All samples will be collected in accordance with the Field Sampling Plan (FSP) and Quality Assurance Project Plan (QAPP) addenda provided in Appendices C and D, respectively. Alluvial groundwater samples will be collected with the pump positioned in the middle of the screen and the bedrock groundwater samples will target a specific zone based on estimated open fracture locations.

Table 7 summarizes the sampling requirements for the baseline and post-injection sampling events. Groundwater samples will be sent to an off site laboratory for the indicated analyses.

The groundwater samples will be labeled and packaged in accordance with the packing and shipping standard operation procedures (SOP) of the Project Plans for the Phase II Investigation of SWMUs and AOCs (CH2M HILL, 2000) and sent to the laboratory to be analyzed. Alluvial wells will be analyzed for TCL VOCs, TOC, sulfate, chloride, and alkalinity. Bedrock samples will be analyzed for TCL VOCs including 1,4 Dioxane, TAL Metals, TOC, sulfate, chloride, and alkalinity. In addition to the parameters currently being analyzed, sulfate concentrations will be monitored in select extraction wells to determine if and at what level biofouling in the GWTP requiring treatment occurs.

Extraction wells 1EW17, 1EW18, 1EW19, 1EW29, and the effluent of the GWTP will be monitored for manganese, chromium, and nickel (and also 1EW29 for sulfate). Sampling will occur weekly for the first month, and biweekly for the following two months after injections. Lab analyses on sulfate, manganese, chromium, and nickel will be analyzed on a 24-hour turnaround time, in order to be able to change the operation of the treatment plant in a timely manner and counteract biofouling.

The bedrock groundwater will also be measured for KMnO_4 using a spectrometer. A spectrometer will be used to determine a quantitative measurement of KMnO_4 in the field during injection activities and each sampling event thereafter. This helps assess the distribution of the oxidant and the decrease in oxidant concentration over time after the injection event. If metals in the bedrock groundwater samples remain below discharge limits for 3 months, they will no longer be analyzed, with concurrence from USEPA and the West Virginia Department of Environmental Protection.

SECTION 4

Project Reporting

Following the completion of the groundwater monitoring described in Section 3, a report will be prepared that documents the Pilot Study conducted in the Solvent Disposal Pit Area of Site 1. Groundwater monitoring results will be summarized in the report. The conclusions of the report will focus on whether the potassium permanganate and sodium persulfate with a steam catalyst were effective at reducing VOC mass present in groundwater at Site 1. Results from groundwater modeling, including the change in downgradient flux, will be included in the report.

As analytical data become available throughout the pilot study, the data will be compiled into tables and graphs and shared with the Partnering Team.

SECTION 5

Project Schedule

The estimated project duration is approximately 9 months following work plan approval (assumed to be April 11, 2005), as shown in the following table.

Proposed Project Milestones and Schedule

Key Project Milestones	Start Date	End Date	Duration (Days)
Work Plan Approval	4/11/2005	4/11/2005	1
Procurement of Project Funds and Mobilization	4/11/2005	4/15/2005	
Installation/development of Monitoring and Injection Wells	4/25/2005	5/11/2005	15
Collection of Baseline Groundwater Samples	5/8/2005	5/11/2005	4
Analysis/Data Validation and Management	5/16/2005	6/15/2005	30
Injection of Sodium Persulfate with Steam Catalyst	5/16/2005	5/26/2005	10
Injection of Potassium Permanganate	5/16/2005	5/26/2005	5
Groundwater Monitoring – 3 Weeks After Injection	6/20/2005	6/21/2005	2
Groundwater Monitoring – 6 Weeks After Injection	7/12/2005	7/13/2005	2
Groundwater Monitoring – 3 Months After Injection	8/29/2005	8/30/2005	2
Groundwater Monitoring – 5 Months After Injection	10/28/2005	10/29/2005	2
Data Validation and Management	11/21/2005	12/21/2005	30
Draft Pilot Study Report	12/22/2005	12/30/2003	6
Document Review	1/9/2006	1/13/2006	5
Final Pilot Study Report	1/16/2006	1/27/2006	5

SECTION 6

References

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CH2M HILL. 1996c. *Site 1 Focused Feasibility Study for Groundwater at Allegany Ballistics Laboratory*. Prepared for Department of the Navy, Atlantic Division, Naval Facilities Engineering Command, Norfolk, Virginia. September.

CH2M HILL. 1995. *Focused Remedial Investigation of Site 1 at Allegany Ballistics Laboratory*. Prepared for Department of the Navy, Atlantic Division, Naval Facilities Engineering Command, Norfolk, Virginia. September.

TABLES

Table 2
Stabalized Groundwater Field Parameters
Solvent Pit Area Pilot Study
Site 1, Allegany Ballistics Laboratory
Rocket Center, West Virginia

STABILIZED FIELD PARAMETERS								
Well ID	DTW (BTOC)	Flow (ml/min)	pH	Cond. μs/cm	Turbidity (ntu)	DO (mg/L)	Temp. (°C)	ORP (mV)
Alluvial Wells - February 2005								
1IW03	20.04	400	6.28	0.409	48.1	2.5	14.76	184
1MW01	18.96	100	6.66	0.641	797	2.8	16.25	179
1IW02	18.54	600	7.12	0.592	121	2.65	16.31	116
1IW01	18.59	500	6.75	0.649	198	0	15.51	163
Bedrock Well - March 2005								
1MW03 - 40' BTOC	20.3	300	6.83	0.515	149	3.28	14.14	-61
1MW03 - 57' BTOC	20.3	500	7.00	0.542	0	5.48	13.50	-70
1MW03 - 87' BTOC	20.3	300	6.95	0.541	108	3.15	13.66	-135
1IW04 - 60' BTOC	19.43	300	6.83	0.515	149	3.28	14.14	-61
1IW04 - 75' BTOC	19.43	500	6.92	0.512	55.5	2.74	13.96	-89
1IW04 - 88' BTOC	19.43	500	6.86	0.511	63	3.97	13.30	-76
1MW02 - 74' BTOC	19.3	600	6.86	0.507	31.6	4.23	13.34	-97
1MW02 - 88' BTOC	19.3	500	6.86	0.511	63	3.97	13.30	-76

Notes:

pH , conductivity, turbidity, dissolved oxygen (DO), temperature, salinity, and oxygen reduction potential (ORP) were recorded in the field using a Horiba U-22©

Depth to Water (DTW) was measured in the field using a water level indicator.

BTOC - below top of casing

Table 3
Soil Sample Results
Solvent Pit Area Pilot Study
Site 1, Allegany Ballistics Laboratory
Rocket Center, West Virginia

Station ID	AS01-1IW01				AS01-1IW02			
Sample ID	AS01-1IW01-9-10	AS01-1IW01-13-14	AS01-1IW01-16-17	AS01-1IW01P-16-17	AS01-1IW02-12-13	AS01-1IW02-16-17	AS01-1IW02-19-20	AS01-1IW02P-19-20
Sample Date	12/22/04	12/22/04	12/22/04	12/22/04	12/21/04	12/21/04	12/21/04	12/21/04
Sample Depth (bgs)	9-10	13-14	16-17	16-17	12-13	16-17	19-20	19-20
Chemical Name								
Volatile Organic Compounds (ug/Kg)								
1,1,1-TRICHLOROETHANE	120 J	1,700 J	28 J	77 J	4 J	38 J	500	220 J
1,1,2-TRICHLOROETHANE	12 UJ	530 R	69 J	1,500 J	11 U	590 R	7 J	5 J
1,1-DICHLOROETHANE	2 J	23 J	10 UJ	450 R	11 U	590 R	26	11 J
1,1-DICHLOROETHENE	2 J	100 J	6 J	390 J	11 U	590 R	68	46 J
1,2-DICHLOROETHYLENE	35 J	3,400 J	100 J	2,300	11 U	91 J	210	220 J
4-METHYL-2-PENTANONE	16 B	8 B	3 B	450 R	11 U	590 R	2 B	2 B
ACETONE	12 UJ	10 UJ	10 UJ	1,500 J	11 U	590 R	7 B	12 UJ
BENZENE	2 J	6 J	10 UJ	450 R	11 U	590 R	13 UJ	12 UJ
CHLOROBENZENE	8 J	5 J	1 J	94 L	11 U	590 R	2 J	2 J
CHLOROFORM	2 J	10 UJ	10 UJ	450 R	11 U	590 R	13 U	12 UJ
CHLOROMETHANE	12 UJ	10 UJ	10 UJ	49 L	11 U	590 R	13 U	12 UJ
CIS-1,2-DICHLOROETHENE	34 J	3,400 J	100 J	2,300	11 U	91 J	210	220 J
CUMENE	12 UJ	10 UJ	10 UJ	4 L	11 U	590 R	13 U	12 UJ
CYCLOHEXANE	11 J	730 J	200 J	450 R	11 U	590 R	13 UJ	12 UJ
ETHYLBENZENE	3 J	2 J	10 UJ	35 L	11 U	590 R	0.8 J	0.5 J
M- AND P- XYLENES	17 J	3 J	10 UJ	110 L	11 U	590 R	3 J	2 J
METHYLENE CHLORIDE	4,100 J	160 J	6,000 J	4,300 J	11 B	11 B	45 B	39 B
O-XYLENE	5 J	2 J	10 UJ	35 L	11 U	590 R	1 J	0.7 J
TETRACHLOROETHENE	190 J	51 J	15 J	190 J	11 U	590 R	2 J	1 J
TOLUENE	25 J	200 J	3 J	3,600 J	11 U	590 R	65 J	31 J
TRANS-1,2-DICHLOROETHENE	2 J	30 J	15 J	450 R	11 U	590 R	13 U	12 UJ
TRICHLOROETHENE	150,000	53,000	180,000	3,600	140	2,400	22,000	15,000
TRICHLOROFLUOROMETHANE	6 J	4 J	8 J	4 L	4 J	590 R	6 J	5 J
XYLENES (TOTAL)	22 J	5 J	10 UJ	140 L	11 U	590 R	4 J	3 J
Total Metals (mg/Kg)								
ALUMINUM	10,600	7,460	2,040	8,310	7,880	8,580	6,810	8,100
ARSENIC	9.8 L	11.9 L	3.1 L	14.7 L	9 L	7.6 L	10.6 L	10.8 L
BARIUM	113	102	26.6 J	123	83.7	103	130	100
BERYLLIUM	0.74 J	0.86 J	0.14 J	0.75 J	0.69 J	0.72 J	0.67 J	0.79 J
CADMIUM	0.7 UL	0.78 UL	0.74 UL	1 L	0.91 UL	0.84 UL	0.93 J	0.8 UL
CALCIUM	5,280	4,340	380 J	1,380	1,650	1,380	1,250	1,300
CHROMIUM	24.1	16.8	3.9	14.2	14.8	16.5	13.4	15.4
COBALT	19.9	12.9	3.1 J	13.2	13.2	11.8	11.5	11.2
COPPER	17.2 L	20.2 L	4.4 J	15.8 L	18.9 L	15.6 L	19.1 L	16.3 L
IRON	30,500	41,000	10,200	38,200	28,700	33,500	34,200	45,100
LEAD	20.5	17.8	4.7	21.8	14.8	15.8	14.2	18.8
MAGNESIUM	1,680	1,370	424 J	1,470	1,440	1,190	1,360	1,550
MANGANESE	990	736	168	904	491	665	750	562
NICKEL	19.6	23.3	9.2 K	25.9	27.4	20.8	21.8	25.9
POTASSIUM	1,110	923 J	288 B	1,060	1,030 J	1,040 J	938 J	1,010
SELENIUM	0.65 UL	0.73 UL	0.72 J	0.7 UL	0.85 UL	0.79 UL	0.79 UL	0.82 J
SILVER	0.94 J	1.2 J	0.56 J	1 J	1.4 J	1.5 J	0.84 J	1.1 J
SODIUM	31.3 B	45.9 B	21.6 B	54.6 J	45.3 B	52.8 J	58.1 J	52.2 J
VANADIUM	24.3	21.8	5.8 J	20.3	20.1	22.4	18.7	22.6
ZINC	75.2 L	74.4 L	19.9 L	66 L	58.9 L	65.2 L	57.1 L	67.7 L
Wet Chemistry (%)								
% SOLIDS	80	82	88	91	81	79	83	87
NITRATE	8.8 J	0.23 B	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
NITRITE	0.5 U	0.31 J	0.47 J	1.1	0.47 J	0.2 J	0.24 J	0.58
SULFATE	38 K	110 K	240 K	310 K	160 K	78 K	71 K	9.2 J
TOTAL ORGANIC CARBON (TOC)	9,600	8,900	2,700	1,700	8,100	6,300	3,300	4,000

B-blank contamination
J-estimated
K-biased high
L-biased low
R-unreliable

U-not detected
UJ- not detected, quantitation limit may be imprecise
UL-not detected, quantitation limit is probably high
bgs-below ground surface

Table 3
Soil Sample Results
Solvent Pit Area Pilot Study
Site 1, Allegany Ballistics Laboratory
Rocket Center, West Virginia

Station ID	AS01-1IW03			AS01-1MW01-10-11		
Sample ID	AS01-1IW03-14-15	AS01-1IW03-16-17	AS01-1IW03-19-20	AS01-1MW01	AS01-1MW01-12-13	AS01-1MW01-15-16
Sample Date	12/21/04	12/21/04	12/21/04	12/22/04	12/22/04	12/22/04
Sample Depth (bgs)	14-15	16-17	19-20	10-11	12-13	15-16
Chemical Name						
Volatile Organic Compounds (ug/Kg)						
1,1,1-TRICHLOROETHANE	23	38	180 J	27 L	18 J	27 L
1,1,2-TRICHLOROETHANE	10 U	10 U	14 J	10 UL	540 R	10 UL
1,1-DICHLOROETHANE	10 U	10 U	10 UJ	10 UL	540 R	3 L
1,1-DICHLOROETHENE	1 J	1 J	3 J	4 L	540 R	2 L
1,2-DICHLOROETHYLENE	19	140	18 J	71 L	93 J	970
4-METHYL-2-PENTANONE	10 U	10 U	32 J	14 B	7 B	1 B
ACETONE	4 J	10 U	10 UJ	10 UL	540 R	10 UL
BENZENE	10 U	10 U	960 R	10 UL	540 R	10 UL
CHLOROETHANE	3 J	4 J	5 J	2 L	12 J	7 L
CHLOROFORM	10 U	10 U	10 UJ	10 UL	540 R	10 UL
CHLOROMETHANE	10 U	10 U	10 UJ	25 L	12 B	12 B
CIS-1,2-DICHLOROETHENE	19	140	18 J	70 L	93 J	970
CUMENE	10 U	10 U	10 UJ	10 UL	540 R	10 UL
CYCLOHEXANE	10 U	10 U	960 R	10 UL	540 R	14 L
ETHYLBENZENE	10 U	10 U	1 J	10 UL	540 R	10 UL
M- AND P- XYLENES	10 U	10 U	2 J	10 UL	540 R	10 UL
METHYLENE CHLORIDE	11 B	13 B	340 J	35 B	15 B	22 B
O-XYLENE	10 U	10 U	0.7 J	10 UL	540 R	10 UL
TETRACHLOROETHENE	8 J	9 J	6 J	9 L	18 J	12 L
TOLUENE	10 U	11	170 J	10 L	17 J	2 L
TRANS-1,2-DICHLOROETHENE	10 U	10 U	10 UJ	1 L	2 L	3 L
TRICHLOROETHENE	7,000	5,100	10,000	4,400	2,600	5,800
TRICHLOROFLUOROMETHANE	6 J	3 J	3 J	7 L	1 J	3 L
XYLENES (TOTAL)	10 U	10 U	3 J	10 UL	540 R	10 UL
Total Metals (mg/Kg)						
ALUMINUM	7,850	5,750	5,400	7,510	7,710	6,400
ARSENIC	9.5 L	11 L	11.6 L	9.6 L	9.8 L	11.3 L
BARIUM	84.4	87.6	80	77.6	79.4	92.5
BERYLLIUM	0.74	0.73 J	0.82 J	0.75 J	0.72 J	0.81 J
CADMIUM	0.52 UL	0.82 UL	0.71 UL	0.7 UL	0.75 UL	0.8 UL
CALCIUM	1,060	796 J	801 J	1,100	1,240	1,050
CHROMIUM	13.4	12.4	14.9	13.2	12.3	15.4
COBALT	13.8	11.4	11.7	12.2	13	11.6
COPPER	17.6 L	16.3 L	18 L	16.1 L	17.8 L	18 L
IRON	31,300	39,400	45,300	32,400	29,400	40,300
LEAD	14.6	14.8	15.2	14.2	14.8	15.9
MAGNESIUM	1,410	1,040	1,020	1,300	1,490	1,130
MANGANESE	598	493	472	528	659	657
NICKEL	22	20.4	22.7	21.4	22.4	23
POTASSIUM	1,020	898 J	793 J	1,030	1,120	842 J
SELENIUM	0.53 J	0.77 UL	0.76 J	0.76 J	0.7 UL	0.75 UL
SILVER	0.82 J	1.4 J	0.13 U	1.3 J	1.2 J	0.91 J
SODIUM	33.7 B	39.3 B	42.6 B	30.9 B	39.4 B	34.5 B
VANADIUM	21.1	20.3	19	20.9	20.6	20.2
ZINC	57.4 L	65.4 L	70.9 L	60.2 L	57 L	66 L
Wet Chemistry (%)						
% SOLIDS	82	80	86	84	84	84
NITRATE	2.6 J	5.1 J	1.1 J	0.5 U	0.24 B	0.5 U
NITRITE	0.5 U	0.06 J	0.17 J	1.7	0.4 J	0.31 J
SULFATE	59 K	110 K	34 K	220 K	75 K	88 K
TOTAL ORGANIC CARBON (TOC)	4,700	1,600	3,600	3,800	6,200	3,500

B-blank contamination
J-estimated
K-biased high
L-biased low
R-unreliable

U-not detected
UJ- not detected, quantitation limit may be imprecise
UL-not detected, quantitation limit is probably high
bgs-below ground surface

Table 4
Alluvial Groundwater Analytical Results
Site 1 Solvent Pit Area Pilot Study Work Plan
Allegany Ballistics Laboratory
Rocket Center, West Virginia

Station ID	1IW01	1IW02	1IW03	1MW01
Sample ID	AS01-1IW01-0205	AS01-1IW01P-0205	AS01-1IW02-0205	AS01-1IW03-0205
Sample Date	2/22/05	2/22/05	2/22/05	2/22/05
Chemical Name				
Volatile Organic Compounds (ug/l)				
1,1,1-TRICHLOROETHANE	1,100	1,100	3,300	1,600
1,1-DICHLOROETHANE	250 U	250 U	76 J	500 U
1,1-DICHLOROETHENE	78 J	67 J	200 J	65 J
1,2-DICHLOROETHYLENE	66 J	61 J	75 J	230 J
CIS-1,2-DICHLOROETHENE	66 J	61 J	75 J	230 J
METHYLENE CHLORIDE	1,600	1,400	120 B	2,900
TOLUENE	100 J	99 J	340	380 J
TRICHLOROETHENE	39,000 J	38,000 J	48,000 J	78,000 J
Total Metals (ug/l)				
ALUMINUM	7,010 K	7,290 K	5,990 K	1,190 K
ARSENIC	3.2 J	3.03 U	3.03 U	3.03 U
BARIUM	134 J	130 J	123 J	90.4 J
BERYLLIUM	0.42 J	0.25 J	0.41 J	0.25 U
CADMIUM	0.3 U	0.3 U	0.3 U	0.35 J
CALCIUM	101,000	102,000	94,800	66,800
CHROMIUM	6.3 B	5.8 B	11.1	3.4 B
COBALT	4.4 B	4.5 B	4.8 B	1.6 B
COPPER	3.2 B	2.4 B	4.8 B	0.86 UL
CYANIDE	10 UL	3.7 J	10 UL	10 UL
IRON	6,120	5,580	8,200	948
LEAD	1.7 U	1.7 U	2.9 J	1.7 UL
MAGNESIUM	18,000	18,100	15,000	12,100
MANGANESE	1,120	1,120	983	1,250
NICKEL	12 B	12 B	14.9 B	8.9 B
POTASSIUM	2,570 B	2,680 J	6,200	1,060 B
SODIUM	13,800	13,900	17,400	6,900
VANADIUM	8 J	8 J	7.6 J	2.2 B
ZINC	15.8 B	16.4 B	19.2 B	10.2 B
Dissolved Metals (ug/l)				
ALUMINUM	17.9 U	17.9 U	22.7 J	18.2 B
BARIUM	75 J	74.3 J	87.5 J	96.2 J
CALCIUM	110,000	108,000	98,100	85,500
MAGNESIUM	19,000	18,800	15,600	15,000
MANGANESE	742	754	682	1,210
POTASSIUM	1,190 B	1,300 B	5,280	1,050 B
SODIUM	15,100	14,900	19,900	9,440
Wet Chemistry (mg/l)				
ALKALINITY	210	200	180	120
CHLORIDE	42	42	31	16
HARDNESS, TOTAL	325,000	329,000	298,000	216,000
NITRATE AS N	0.63 B	0.63 B	0.93 B	3.2
NITRITE AS N	0.021 J	0.015 J	0.046 J	0.024 J
PHOSPHATE, ORTHO-ASCORBIC ACID	0.047 J	0.05	0.059	0.026 J
SOLIDS- FILTERABLE RESIDUE	370	180	390	260
SOLIDS- NONFILTERABLE RESIDUE	110	100	84	81
SULFATE	82	81	79	54

B-blank contamination
J-estimated
K-biased high

U-not detected
UL-not detected, quantitation limit is probably high

Table 5
Bedrock Groundwater Analytical Results
Site 1 Solvent Pit Area Pilot Study Work Plan
Allegany Ballistics Laboratory
Rocket Center, West Virginia

Station ID	11W04			
Sample ID	AS01-11W04-60-0305	AS01-11W04-75-0305	AS01-11W04-88-0305	AS01-11W04P-88-0305
Sample Date	3/11/05	3/10/05	3/10/05	3/10/05
Sample Depth (BTOC)	60	75	88	88
Chemical Name				
Volatile Organic Compounds (ug/l)				
1,1,1-TRICHLOROETHANE	750	8 J	12	12
1,1,2-TRICHLOROETHANE	7 J	10 U	10 U	10 U
1,1-DICHLOROETHANE	19	7 J	12	13
1,1-DICHLOROETHENE	120	8 J	14	14
1,2-DICHLOROETHYLENE	50	380	820	840
4-METHYL-2-PENTANONE	10 UJ	10 U	10 U	10 U
ACETONE	10 U	10 U	10 U	10 U
BENZENE	10 UJ	10 U	10 U	10 U
CHLOROBENZENE	10 U	10 U	10 U	10 U
CHLOROFORM	10 U	10 U	10 U	10 U
CIS-1,2-DICHLOROETHENE	49	380	820	840
CYCLOHEXANE	2 J	10 U	10 U	10 U
ETHYLBENZENE	10 U	10 U	10 U	10 U
M- AND P- XYLENES	10 U	10 U	10 U	10 U
METHYLENE CHLORIDE	56	10 U	2 B	2 B
TETRACHLOROETHENE	10 UJ	10 U	10 U	10 U
TOLUENE	5 J	2 J	3 J	4 J
TRANS-1,2-DICHLOROETHENE	1 J	2 J	4 J	4 J
TRICHLOROETHENE	16,000	880	1,600	1,600
VINYL CHLORIDE	10 U	6 J	10	11
XYLENES (TOTAL)	10 U	10 U	10 U	10 U
Total Metals (ug/l)				
ALUMINUM	66.9 B	20.5 U	69.1 B	63.4 B
BARIUM	72.4 J	59.6 J	67.5 J	70 J
CALCIUM	127,000	118,000	120,000	120,000
CHROMIUM	1 U	1.2 J	1.1 J	1.5 J
COBALT	4.3 U	4.3 U	4.3 U	4.3 U
COPPER	5.4 B	2.52 U	35.3	20.6 J
IRON	1,830	1,350	1,530	1,490
MAGNESIUM	19,600	24,300	23,900	23,800
MANGANESE	380	148	146	144
NICKEL	11.6 U	11.6 U	11.6 UL	11.6
POTASSIUM	1,090 J	2,350 J	2,560 J	2,380 J
SODIUM	21,500	19,400	22,900	22,800
ZINC	2.9 B	5.3 B	6.6 B	14.3 J
Dissolved Metals (ug/l)				
ARSENIC	2.81 UL	2.81 UL	2.9 B	NA
BARIUM	67.2 J	59.7 J	66.2 J	NA
CALCIUM	119,000	118,000	116,000	NA
IRON	1,320	1,280	1,230	NA
MAGNESIUM	18,800	24,200	23,300	NA
MANGANESE	355	146	135	NA
POTASSIUM	1,160 J	2,450 J	2,240 J	NA
SODIUM	20,800	19,600	22,400	NA
VANADIUM	5.2 J	5.07 U	5.07 U	NA
Wet Chemistry (mg/l)				
ALKALINITY	230	260	240	260
CHLORIDE	60	39	44	44
HARDNESS, TOTAL	397,000	396,000	399,000	397,000
NITRATE	0.59 K	0.05 U	0.05 U	0.05 U
NITRITE	0.05 U	0.05 U	0.05 U	0.05 U
PHOSPHATE, ORTHO-ASCORBIC ACID	0.05 U	0.05 U	0.05 U	0.24
SOLIDS- FILTERABLE RESIDUE	410	420	430	430
SOLIDS- NONFILTERABLE RESIDUE	9.2	4 U	10	8.8
SULFATE	58	82	90	88

B-blank contamination

J-estimated

K-biased high

L-biased low

U-not detected

UJ- not detected, quantitation limit may be imprecise

UL-not detected, quantitation limit is probably high

BTOC-below top of casing

Table 5
Bedrock Groundwater Analytical Results
Site 1 Solvent Pit Area Pilot Study Work Plan
Allegany Ballistics Laboratory
Rocket Center, West Virginia

Station ID	1MW02		1MW03		
Sample ID	AS01-1MW02-74-0305	AS01-1MW02-88-0305	AS01-1MW03-40-0305	AS01-1MW03-57-0305	AS01-1MW03-87-0305
Sample Date	3/11/05	3/11/05	3/11/05	3/10/05	3/11/05
Sample Depth (BTOC)	74	88	40	57	87
Chemical Name					
Volatile Organic Compounds (ug/l)					
1,1,1-TRICHLOROETHANE	250 J	830 J	220 J	270	560
1,1,2-TRICHLOROETHANE	4 J	21 J	2 J	1 J	17 J
1,1-DICHLOROETHANE	19	180	33	15	170
1,1-DICHLOROETHENE	39	210 J	48	43	170
1,2-DICHLOROETHYLENE	340 J	730 J	400	480	2,300
4-METHYL-2-PENTANONE	3 J	46 J	10 U	10 U	20 J
ACETONE	10 U	10 U	2 J	10 U	10 U
BENZENE	2 J	10 UJ	10 U	10 U	9 J
CHLOROBENZENE	10 U	2 J	10 U	10 U	1 J
CHLOROFORM	10 U	1 J	10 U	10 U	10 Y
CIS-1,2-DICHLOROETHENE	340 J	730 J	400	480	2,300
CYCLOHEXANE	6 J	15 J	1 J	10 U	13 J
ETHYLBENZENE	10 U	1 J	10 U	10 U	10 U
M- AND P- XYLENES	1 J	3 J	10 U	10 U	1 J
METHYLENE CHLORIDE	82	1,600 J	52	8 B	570 J
TETRACHLOROETHENE	1 J	4 J	10 U	10 U	2 J
TOLUENE	110 J	290 J	12	2 J	190 J
TRANS-1,2-DICHLOROETHENE	3 J	15	3 J	3 J	21
TRICHLOROETHENE	27,000	110,000	9,500	6,200	51,000
VINYL CHLORIDE	2 J	11	5 J	4 J	35
XYLENES (TOTAL)	1 J	3 J	10 U	10 U	1 J
Total Metals (ug/l)					
ALUMINUM	150 B	384	453	20.5 U	219
BARIUM	73.5 J	69.4 J	64.2 J	61.5 J	77.7 J
CALCIUM	119,000	117,000	117,000	125,000	127,000
CHROMIUM	2.2 B	2.7 B	1 U	1 J	1 U
COBALT	4.3 U	4.3 U	4.3	4.3 U	4.3 U
COPPER	41	55.4	30	2.52 U	42
IRON	2,300	1,480	8,130	634	1,260
MAGNESIUM	22,600	22,400	21,100	22,800	22,600
MANGANESE	134	134	320	305	141
NICKEL	11.6 U	13.9 B	12.6 B	11.6 U	11.6 U
POTASSIUM	2,790 J	3,610 J	2,090 J	1,590 J	3,130 J
SODIUM	15,500	15,400	18,800	20,100	22,300
ZINC	2.8 B	6.2 B	8.9 J	4.1 B	4.4 B
Dissolved Metals (ug/l)					
ARSENIC	2.81 UL	16.6 L	2.81 UL	2.81 UL	21.3
BARIUM	71.4 J	66 B	62.2 J	59.8 J	75.1 J
CALCIUM	115,000	119,000	120,000	121,000	127,000
IRON	2,010	894	5,680	566	765
MAGNESIUM	22,000	22,600	21,700	21,900	22,400
MANGANESE	126	123	313	293	134
POTASSIUM	2,400 J	3,490 J	1,920 J	1,530 J	2,940 J
SODIUM	15,500	16,000	19,700	19,200	22,700
VANADIUM	5.07 U	5.07 U	5.07 U	5.07 U	5.07 U
Wet Chemistry (mg/l)					
ALKALINITY	240	250	250	240	250
CHLORIDE	34	37	49	48	52
HARDNESS, TOTAL	389,000	383,000	379,000	406,000	410,000
NITRATE	0.05 U	0.05 U	0.25 K	0.05 U	0.0043 J
NITRITE	0.05 U	0.05 U	0.0076 J	0.05 U	0.05 U
PHOSPHATE, ORTHO-ASCORBIC ACID	0.049 J	0.058	0.16	0.05 U	0.03 J
SOLIDS- FILTERABLE RESIDUE	420	460	480	330	490
SOLIDS- NONFILTERABLE RESIDUE	30	55	39	4 U	26
SULFATE	78	78	71	72	82

B-blank contamination

J-estimated

K-biased high

L-biased low

U-not detected

UJ- not detected, quantitation limit may be imprecise

UL-not detected, quantitation limit is probably high

BTOC-below top of casing

Table 7
Groundwater Sampling Requirements and Schedule
Solvent Pit Area Pilot Study Work Plan
Site 1, Allegany Ballistics Laboratory
Rocket Center, West Virginia

GROUNDWATER SAMPLES					Sampling Round										
Station ID	Sampling Zone	Expected Sample Interval (ft bgs)	Sample ID	Sample Media	Baseline	1-Week	2-Week	3-Week	4-Week	6-Week	8-Week	2-Month	2.5-Month	3 -Month	5-Month
Alluvial Aquifer Wells															
1IW01	Alluvial	20-30	AS01-1IW01-MMY	Groundwater	E										
1IW02	Alluvial	20-30	AS01-1IW02-MMY	Groundwater	E										
1IW03	Alluvial	20-30	AS01-1IW03-MMY	Groundwater	E										
1IW05	Alluvial	20-30	AS01-1IW05-MMY	Groundwater	A										
1IW06	Alluvial	20-30	AS01-1IW06-MMY	Groundwater	A										
1IW07	Alluvial	20-30	AS01-1IW07-MMY	Groundwater	A										
1IW08	Alluvial	20-30	AS01-1IW08-MMY	Groundwater	A										
1MW01	Alluvial	20-30	AS01-1MW01-MMY	Groundwater	E			A		A				A	A
1MW06	Alluvial	20-30	AS01-1MW06-MMY	Groundwater	A			A		A				A	A
1MW07	Alluvial	20-30	AS01-1MW07-MMY	Groundwater	A			A		A				A	A
1MW08	Alluvial	20-30	AS01-1MW08-MMY	Groundwater	A			A		A				A	A
1MW09	Alluvial	20-30	AS01-1MW09-MMY	Groundwater	A			A		A				A	A
1MW10	Alluvial	20-30	AS01-1MW10-MMY	Groundwater	A			A		A				A	A
1MW11S	Alluvial	12-22	AS01-1MW11S-MMY	Groundwater	A			A		A				A	A
1MW11D	Alluvial	22-30	AS01-1MW11D-MMY	Groundwater	A			A		A				A	A
Bedrock Aquifer Wells ¹															
1IW04	Bedrock	57.5	AS01-1IW04-60-0305	Groundwater	E										
	Bedrock	72.5	AS01-1IW04-75-0305	Groundwater	E										
	Bedrock	86.5	AS01-1IW04-88-0305	Groundwater	E										
1MW02	Bedrock	71.5	AS01-1MW02-74-0305	Groundwater	E			B		B				B	B
	Bedrock	86.5	AS01-1MW02-88-0305	Groundwater	E			B		B				B	B
1MW03	Bedrock	38.5	AS01-1MW03-40-0305	Groundwater	E			B		B				B	B
	Bedrock	55.5	AS01-1MW03-57-0305	Groundwater	E			B		B				B	B
	Bedrock	84.5	AS01-1MW03-87-0305	Groundwater	E			B		B				B	B
1MW04	Bedrock	TBD	AS01-1MW04-MMY	Groundwater	B			B		B				B	B
	Bedrock	TBD	AS01-1MW04-MMY	Groundwater	B			B		B				B	B
1MW05	Bedrock	TBD	AS01-1MW05-MMY	Groundwater	B			B		B				B	B
	Bedrock	TBD	AS01-1MW05-MMY	Groundwater	B			B		B				B	B
Extraction Wells															
1EW29 ²	Bedrock		AS01-1EW29-MMY	Groundwater	B	D	D	B	D	B	D	D	D	B	B
1EW17	Alluvial		AS01-1EW17-MMY	Groundwater	B	C	C	B	C	B	C	C	C	B	B
1EW18	Alluvial		AS01-1EW18-MMY	Groundwater	B	C	C	B	C	B	C	C	C	B	B
1EW19	Alluvial		AS01-1EW19-MMY	Groundwater	B	C	C	B	C	B	C	C	C	B	B
GWTP	NA		AS01-1GWTP-MMY	Groundwater	C	C	C	C	C	C	C	C	C	C	C
Field QA/QC Samples		Duplicates	AS01-XXXXXXP-MMY	QC	2			2		2				2	2
		MS/MSDs	AS01-XXXXXX-MMY MS/MSD	QC	1			1		1				1	1
		Trip Blank ³	AS01-TB[MMDDYY]-MMY	QC	2			2		2				1	1
		Field Blank	AS01-FB[MMDDYY]-MMY	QC	1			1		1				1	1
		Equipment Blank ⁴	AS01-EB[MMDDYY]-MMY	QC	1			1		1				1	1

Analytical Parameters:

- A - TCL VOCs; TOC; Sulfate; Chloride; Alkalinity, and 1,4 Dioxane.
B - TCL VOCs; TAL Metals; Sulfate; TOC; Chloride; Alkalinity; and 1,4 Dioxane
C - Manganese, Chromium, and Nickel
D - Sulfate, Manganese, Chromium, and Nickel
E - Baseline groundwater samples were collected during the Site Characterization Phase. See Table 5 for analytical results.

Notes:

1. If Ni, Cr, or Mn concentrations remain below discharge limits for 3 months they will no longer be analyzed.
2. Only TAL Metals in bedrock monitoring wells that are elevated during the 3-week sampling event will be monitored thereafter.
3. The actual number of trip blanks to be sent to the analytical laboratory will be determined by the number of coolers containing TCL VOC samples. The sample ID of trip blanks (and field and equipment blanks) will be determined based upon the day that it was shipped to the analytical laboratory.
4. The actual number of equipment blanks to be collected will be based upon the number of days it takes to perform sampling.
All samples will be placed on ice in the coolers from sample collection time until the samples arrive at the laboratory.

NS - No Samples

TBD - To be determined

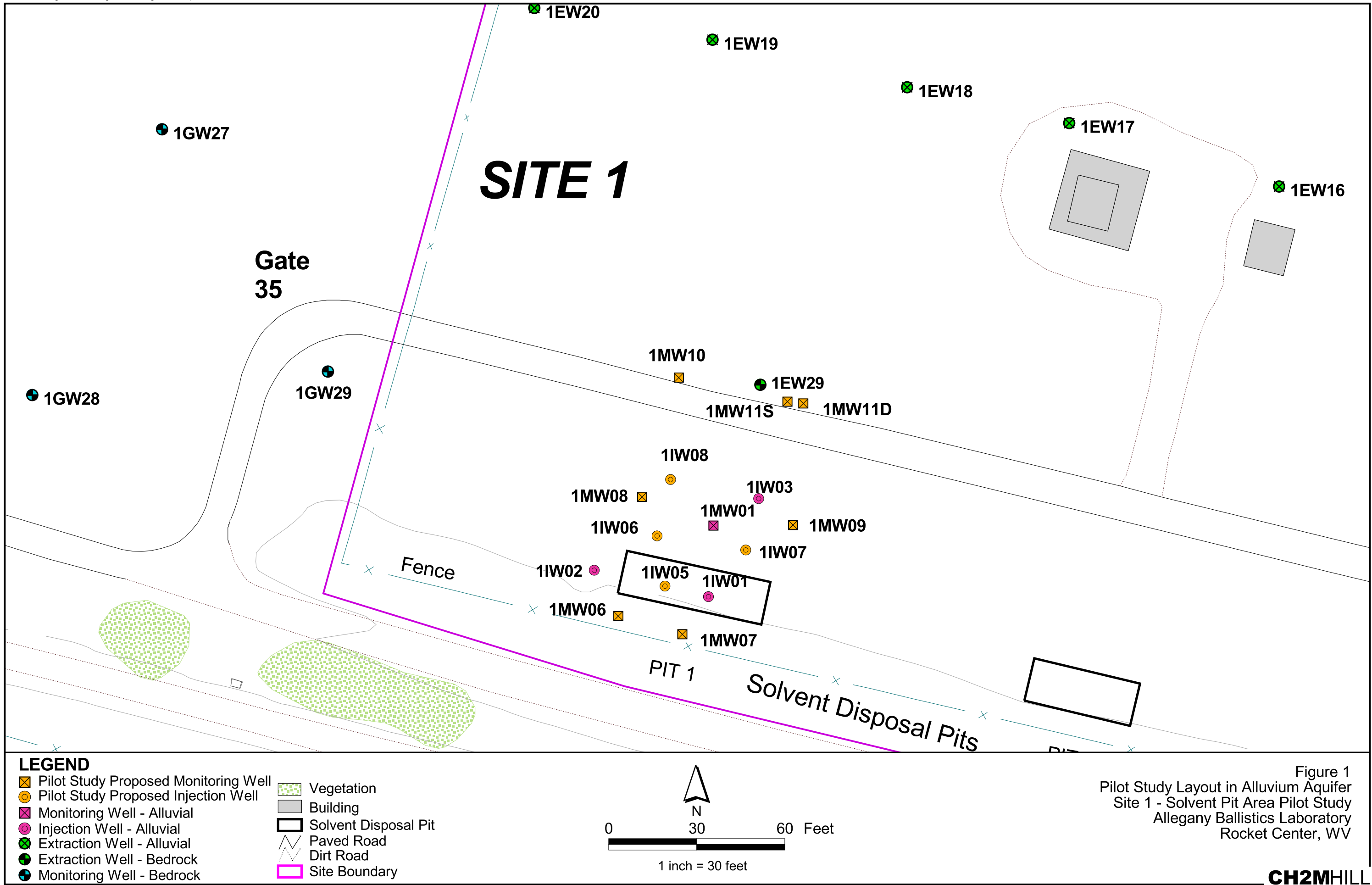
GWTP - Groundwater Treatment Plant

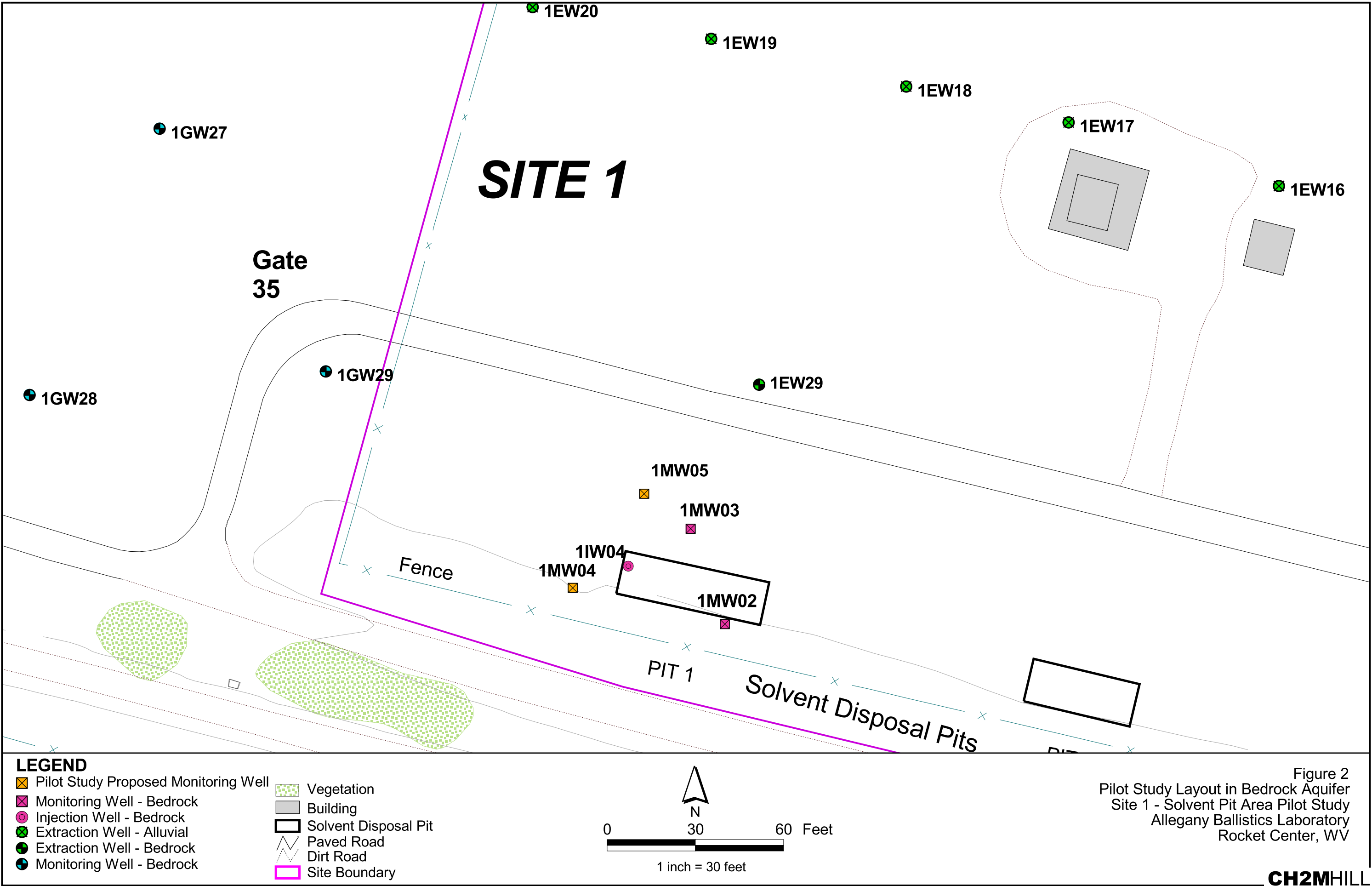
Table 8
Post Injection Estimated VOC Concentration
Solvent Pit Area Pilot Study Work Plan
Site 1, Allegany Ballistics Laboratory

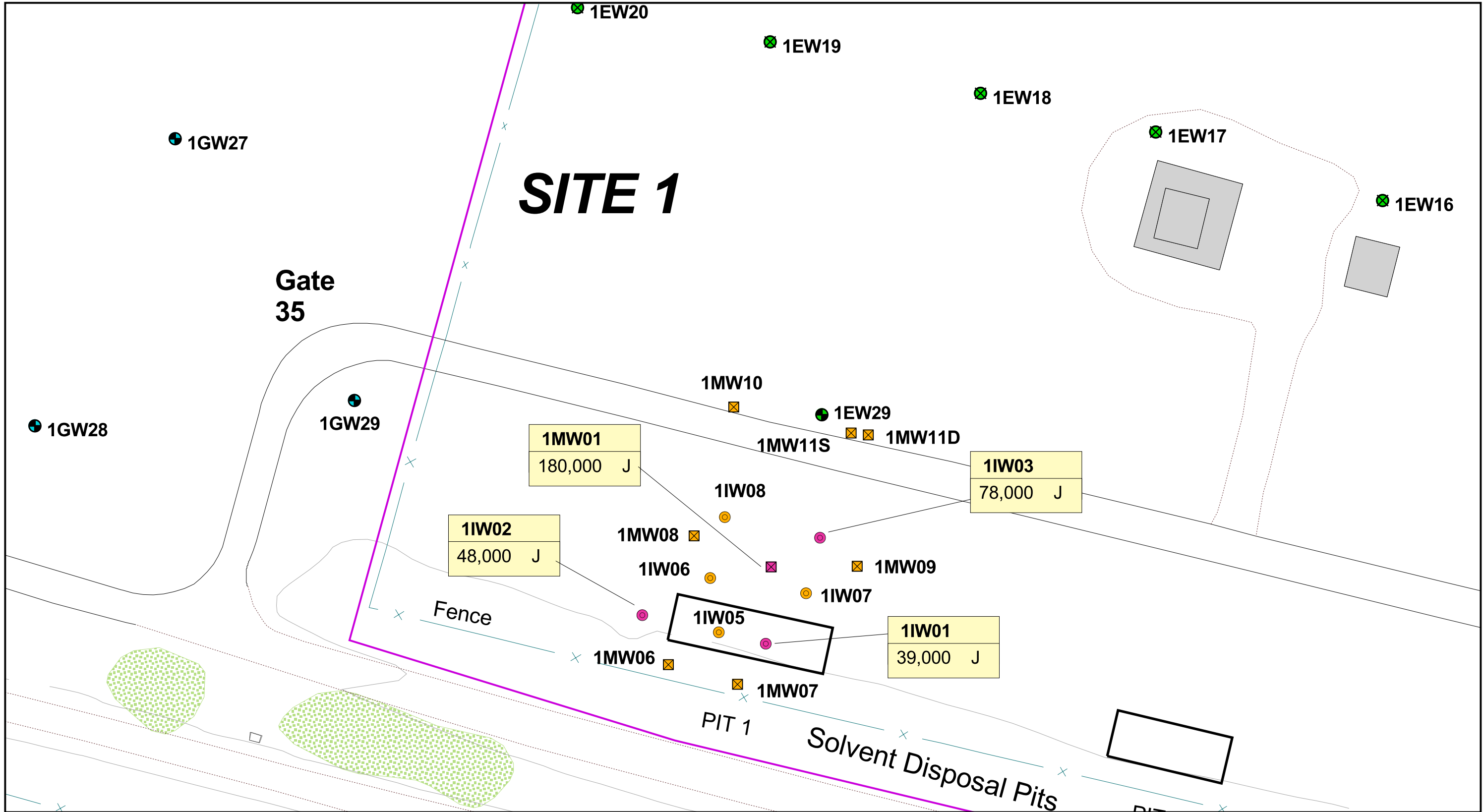
Well ID	gpm	L/min	Total VOC 2003 (odd)/ 2002 (even)	Post- Injection Conc (ug/L)	Additional Total VOC Load from Typical Loading	Addtl Load Total VOC mass/min (ug)
1EW17	0.66	2.49	68,061	180000	111,939	278,649
1EW18	0.65	2.47	36,217	180000	143,783	355,386
1EW19	0.43	1.64	56,490	180000	123,510	202,735
1EW29	4.87	18.42	6	110000	109,995	2,026,268
Total:	6.61					2,863,038

Estimated Concentration post-injection if total VOCs concentration increases to:			180000 ug/L	on EW17, 18, 19
			110000 ug/L	on EW29
2004 Stripper Influent	203.7	771.00	4010	
2004 Total Mass for Stripper influent (ug/min)=			3,091,728	
Estimated Mass Loading post injection (ug/min)=			5,954,766	
Estimated Influent concentration post injection			7,723	ug/L

FIGURES







LEGEND

- ☒ Pilot Study Proposed Monitoring Well
- Pilot Study Proposed Injection Well
- ☒ Monitoring Well - Alluvial
- Injection Well - Alluvial
- ☒ Extraction Well - Alluvial
- Extraction Well - Bedrock
- Monitoring Well - Bedrock
- ▨ Vegetation
- ▨ Building
- ▭ Solvent Disposal Pit
- Paved Road
- - - Dirt Road
- ▭ Site Boundary

Notes:
All units in micrograms per liter
J - Estimated value

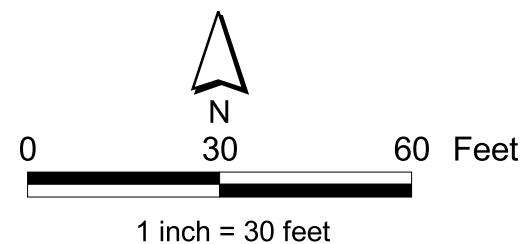
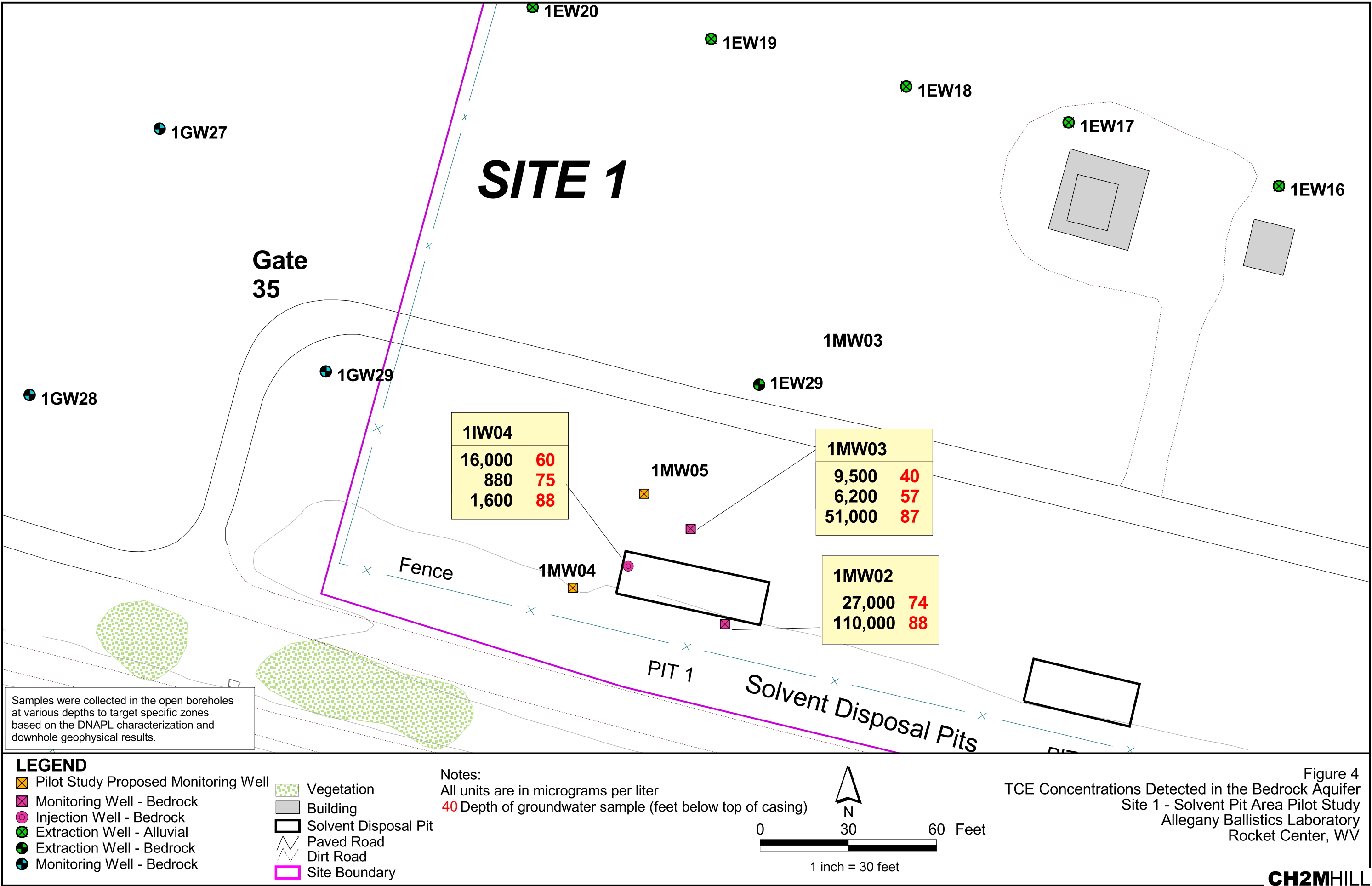


Figure 3
TCE concentrations Detected in the Alluvium Aquifer
Site 1 - Solvent Pit Area Pilot Study
Allegany Ballistics Laboratory
Rocket Center, WV



Appendix A
Bench Scale Test Results and Analysis

1.0 Introduction

This report describes bench scale tests and laboratory analytical tests that were conducted to determine the appropriate oxidant for pilot tests at the Solvent Pit Area of Site 1 at Allegany Ballistics Laboratory (ABL) in Rocket Center, West Virginia. The primary purpose of the pilot test is to determine if In Situ Chemical Oxidation (ISCO) is effective or feasible in reducing contaminant mass at Site 1. Based upon an initial review of oxidants, sodium persulfate and potassium permanganate were selected as the oxidants for the bench-scale treatability study. The focus of the study is on heated sodium persulfate, but oxidant demand tests were also completed with potassium permanganate. The long-term goal for the pilot test is to identify a technology that will cost-effectively reduce contaminant mass in the areas of Site 1 groundwater that may contain dense non-aqueous phase liquids (DNAPLs) with the intent to expedite remediation and/or reduce life-cycle cost of the current pump and treat system.

A bench-scale test was conducted to determine the site-specific quantities of oxidants required to treat the contaminant mass in the subsurface, to determine the effectiveness of oxidants on site VOCs, and to estimate potential changes in dissolved metal concentrations resulting from oxidant injection. Bench scale results and descriptions are provided in Appendix A.

2.0 Sample Receipt/Description

On February 11, Analytical Environmental Services (AES) received soil and groundwater samples for Redox Tech collected from Site 1 of the Allegany Ballistics Laboratory on February 9 and 10. The samples consisted of two 1-liter glass jars containing alluvial soil (sample ID# AS01-1IW01-0205) and two 1-liter amber bottles of groundwater (sample ID# AS01-1MW18-0205). One of the soil jars was cracked but still relatively well sealed with the tape used to hold and protect the label. This jar was sealed in a fresh 1-gallon Ziploc bag. The cooler was placed in a walk-in refrigerator maintained at or below 4C until the samples were prepared on February 14.

3.0 Treatability Tests and Sample Preparations

The soil and water samples were used for three tests. The first test was the VOC treatability test. This test was setup to compare the initial VOC content in groundwater (SW 846 Method 8260B) to the VOC content in groundwater that was premixed with a known weight of soil. The mixture of soil and groundwater was managed in one of three ways: 1) untreated and maintained at ambient temperature; 2) dosed with oxidant and heated to 45C; and 3) heated to 45C with no oxidant added. An initial VOC groundwater sample set (two 40-ml VOAs) was collected from one of the 1-L amber bottles on Feb 14 and submitted to the laboratory (AES) for analysis. Then, 16 VOAs (40 ml Teflon septa sealed vials) were prepared with approximately 8.0 to 8.5 g of soil. Sodium persulfate was

added to 6 of the vials (1 ml of a 75g/L solution), and then each vial was filled completely with groundwater and sealed with no headspace. All of the vials were then vigorously shaken for approximately 30 seconds. Five of the sample vials without oxidant, and the six oxidant-dosed vials were placed in a heated water bath set at about 45°C. The remaining five untreated samples were left at room temperature. Select vials were removed (“collected”), labeled for analysis, and placed on ice after 24 and 96 hrs of treatment. The sample IDs used in the COCs submitted to the laboratory, and the sample “collection” and submission dates are provided in Table 1 below.

The second test conducted was to determine the TOD of combined soil and groundwater samples. Three samples were prepared using approximately 100 g of soil, 1 g of oxidant, and 100 ml of groundwater in a 500 ml polyethylene bottle. Two sodium persulfate samples and one potassium permanganate sample were prepared. The samples were securely capped and vigorously shaken for about 15 to 20 seconds. In addition to the test samples, three control samples were prepared; two oxidant controls (1 g of oxidant with 100 ml of deionized water) and one control blank (100 ml of deionized water). The samples were maintained at room temperature for 3 days after which they were titrated to determine the amount of oxidant consumed. TOD testing for permanganate was completed per Haselow et al., 2003. Estimating the Total Oxidant Demand for In Situ Chemical Oxidation Design, Remediation, Autumn, 2003, with a slight modification to the persulfate titration technique.

The third test conducted was for metals leaching. This test was setup to compare the initial total metals content in groundwater (SW 846 Method 6010B and 7470A) to the metals content in groundwater that was premixed with a known weight of soil and then treated in one of three ways: 1) no further treatment; 2) treatment with sodium persulfate; and 3) treatment with potassium permanganate. Insufficient (< 1.3 L) groundwater remained from the 2 liters collected in the field to ensure that adequate water volume could be obtained from the leach tests. Therefore, an approximate 200 ml aliquot of groundwater collected during the December 21-22 sampling event was added to the remaining groundwater. The older sample had been kept at < 4 °C upon receipt on December 28. Although the groundwater was not otherwise preserved, it is not likely that the metals content of the water differed significantly from that collected in February. Once the groundwater was mixed, an initial groundwater sample was collected and submitted to the laboratory for analysis. Six samples were prepared in 500 ml polyethylene bottles using from 75 to 80 g of soil and 200 ml of groundwater. Two of the samples included a 1 g dose of sodium persulfate and two samples included a 1 g dose of potassium permanganate (effective oxidant dose of 13 g/kg of soil). All of the samples were shaken vigorously for 15 to 20 seconds and maintained for 3 days at ambient temperature. After 3 days, the persulfate and permanganate samples were treated with reductants to remove excess oxidant. The reductants (potassium iodide and sodium thiosulfate for the persulfate samples and sodium thiosulfate for the permanganate samples) were added in excess of the required mass based on the results of the TOD tests. Following reduction, the samples were allowed to settle for 24 hrs after which water samples were collected by pipette from each bottle. The samples were labeled and submitted for analysis to AES. The sample IDs used in the COCs

submitted to the laboratory, and the sample “collection” and submission dates are provided in Table 1 below.

Table 1. Analytical Laboratory Sample IDs with Collection and Submission Dates

Test and Sample Description		Sample ID	Collection Date*	Submission Date**
VOC (8260B)	Initial Groundwater	GWVOC	Feb 14, 2005	Feb 14, 2005
	Oxidant + Heat, 24 hr	TS1	Feb 15, 2005	Feb 17, 2005
	Oxidant + Heat, 24 hr duplicate	TS2	Feb 15, 2005	Feb 17, 2005
	Heat, 24 hr	TS3	Feb 15, 2005	Feb 17, 2005
	Control, 24 hr	TS4	Feb 15, 2005	Feb 17, 2005
	Oxidant + Heat, 96 hr	TS5	Feb 18, 2005	Feb 18, 2005
	Heat, 96 hr	TS6	Feb 18, 2005	Feb 18, 2005
	Control, 96 hr	TS7	Feb 18, 2005	Feb 18, 2005
Metals Leach (6010B and 7470A)	Initial Groundwater	GWTM	Feb 14, 2005	Feb 14, 2005
	Persulfate	LS1	Feb 17, 2005	Feb 18, 2005
	Permanganate	LM1	Feb 17, 2005	Feb 18, 2005
	Control	LC1	Feb 17, 2005	Feb 18, 2005

* The collection date for metals leaching is the date the samples were reduced.

4.0 Results of the Treatability Tests

The results of the tests are provided in Tables 2 through 4. The analytical laboratory reports from AES are attached to this report.

Table 2 lists the results of the TOD tests. The soils have a relatively high oxidant demand evident from the permanganate TOD of 6.7 g/kg. The persulfate demand is about one-fifth that of permanganate, which is typically the case for uncatalyzed samples. However, there is still a significant demand, and combined with the fact that the sample was not catalyzed, indicates that there are appreciable reduced metals in the soils that are being oxidized by the persulfate. These metals may serve to catalyze the persulfate in addition to simply acting as oxidant sinks. The presence of oxidizable metals in the soils is supported in the results of the metals leaching tests discussed below and listed in Table 4.

The results of the VOC tests are presented in Table 3. The results are very encouraging and indicate that the heat-catalyzed persulfate will degrade the chlorinated ethenes and ethanes. However, as expected, the ethanes (e.g. 1,1,1-trichloroethane) require longer reaction times to achieve appreciable destruction (higher persulfate dosing may also increase the destruction rate). Following four days of treatment, all compounds except TCE are below

reporting limits and the TCE has been reduced by more than 99.9%. The untreated control was relatively stable. The heat-treated control concentrations dropped approximately 10% after 24 hrs and by about 30% after 96 hrs.

The initial results of the metals impact from oxidation are provided in Table 4. All of the samples had elevated chromium, including the control after treatment. It is unclear why the control sample had elevated chromium; it possibly might be turbidity, but the sample was relatively clear. Chemical oxidation can result in temporary production of soluble chromium, but once the oxidant is consumed, the soluble chromium dissipates. The sample treated with persulfate also had elevated levels of selenium and arsenic. The pH of the persulfate treated sample was made alkaline to a pH of 9. Typically, injections of persulfate are made at a pH of 9 so that the solution is not so corrosive to ferrous metals (iron solubility decreases with increasing pH). The solubility of arsenic and selenium was likely the result of the higher pH. As a result, soil and groundwater that was stored was mixed with persulfate and the pH was increased to 8 rather than 9, which is slightly less alkaline. In general, metals are less soluble at more neutral pH, as confirmed by the results.

Table 2. Results of Total Oxidant Demand Tests

Sample ID	Oxidant Demand (g/kg)
Persulfate	1.3
Persulfate Duplicate	1.5
Permanganate	6.7

TOD is reported in grams of oxidant per kilogram of saturated aquifer material.

TOD testing for permanganate completed per Haselow *et al.*, 2003. Estimating the Total Oxidant Demand for In Situ Chemical Oxidation Design, Remediation, Autumn, 2003. TOD testing for persulfate completed per assay procedures in FMC Persulfates Technical Information bulletin. Persulfate samples were not heat catalyzed.

Table 3. Results of Method 8260B Analyses of VOCs in Groundwater and Soil-Water Treatability Tests

Compound	Sample Description and Water Concentrations (ug/L)							
	Initial Ground water	Untreated Soil + GW		Heated Soil + GW		Heat Catalyzed Persulfate Soil + GW		
		24 hr	96 hr	24 hr	96 hr	24 hr	24 hr dup	96 hr
Soil Mass:	0	8.66 g	8.28 g	8.23 g	8.12 g	8.02 g	8.31 g	8.14 g
1,1,1-Trichloroethane	800	730	790	710	560	490	710	< 5.0
1,1-Dichloroethane	30	< 250	< 250	< 250	< 250	11	< 250	< 5.0
1,1-Dichloroethene	84	< 250	< 250	< 250	< 250	< 5.0	< 250	< 5.0
cis-dichloroethene	2,600	2,300	2,400	2,200	2,000	< 5.0	< 250	< 5.0
trans-dichloroethene	17	< 250	< 250	< 250	< 250	< 5.0	< 250	< 5.0
Trichloroethene	40,000	41,000	39,000	36,000	28,000	210	640	14
Vinyl Chloride	9.2	< 100	< 100	< 100	< 100	< 2.0	< 100	< 2.0

All other VOCs were below reporting limits except for low concentrations of acetone (45 ug/L) and methylene chloride (18 ug/L) detected in the persulfate treated 24 hr sample. These compounds are typical laboratory contaminants and were most likely introduced into the sample after receipt or during analysis. Note that due to the soil water matrix present in the vials, select samples had to be diluted and the reporting limits were increased above the method detection limits.

The results of the metals leaching tests are presented in Table 4.

Table 4. Results of Methods 6010B/7470A Analyses of Total Metals in Groundwater and Soil-Water Treatability Tests

Metal	Sample Description and Water Concentrations (mg/L)					
	MCL (* Region 3 RBC)	Original Groundwater	Untreated Soil + GW	Persulfate Treated Soil + GW, pH 9 (not heat catalyzed)	Persulfate Treated Soil + GW, pH 8 (not heat catalyzed)	Permanganate Treated Soil + GW
Aluminum	37 *	0.471	0.740	< 0.200	<0.200	< 0.200
Arsenic	0.05	< 0.0500	< 0.0500	0.171	< 0.0500	< 0.0500
Barium	2	0.0627	0.0658	0.329	0.208	< 0.0500
Calcium	NA	52.9	70.1	227	101	35.1
Chromium	0.1 (Total)	< 0.0100	1.98	15.3	<0.01	12.3
Copper	1.5 *	< 0.0100	< 0.0100	0.0176	0.0148	< 0.0100
Iron	11 *	< 0.100	0.768	0.205	0.165	< 0.100
Lead	0.015	< 0.0100	< 0.0100	0.0137	<0.01	< 0.0100
Magnesium	NA	10.1	10.9	30.7	13.6	12.8
Manganese	5.1 *	1.67	1.14	3.89	0.203	0.574
Nickel	0.1	< 0.0200	< 0.0200	0.0380	<0.02	< 0.0200
Potassium	NA	1.12	7.07	2150	25.9	583
Selenium	0.05	< 0.0200	< 0.0200	0.0820	<0.02	< 0.0200
Sodium	NA	8.57	16.6	2570	870	282
Tin	22 *	< 0.0500	< 0.0500	0.0555	<0.05	< 0.0500
Zinc	11 *	< 0.0200	0.0220	< 0.0200	<0.02	< 0.0200
Mercury	0.002	NA	< 0.00020	< 0.00020	NA	0.00020

All other metals were below reporting limits.

NA - not analyzed

Persulfate and permanganate treated samples were reduced prior to analysis (see text)

Appendix B
Bedrock Well Geophysical Description

Appendix B
Well 1MW02 Acoustic Televiwer Description
Solvent Pit Area Pilot Study Work Plan
Site 1, Allegany Ballistics Laboratory

Zone: 24.7 - 88.3 below ground surface							
Number on Dips Table	Depth (feet)	Azimuth (degrees)	Strike (degrees)	Dip (degrees)	Upper Depth (feet)	Lower Depth (feet)	Description
7	43.639	N133	N043	20.4SE	43.559	43.718	Continuous open fracture(s)
6	47.959	N132	N042	66.4SE	47.456	48.461	Partial Open Fracture Possible
5	53.68	N134	N044	81.7SE	52.527	54.834	Partial Open Fracture
4	57.92	N301	N211	58.5NW	57.447	58.392	Partial Open Fracture
3	65.43	N123	N033	79.6SE	64.438	66.421	Sealed Feature
2	75.79	N113	N023	60.4SE	75.423	76.158	Partial Open Fracture
1	84.705	N123	N033	25.4SE	84.613	84.797	Partial Open Fracture

Appendix B
Well 1MW03 Acoustic Televiewer Description
Solvent Pit Area Pilot Study Work Plan
Site 1, Allegany Ballistics Laboratory

Zone: 27.8 - 86.9 below ground surface							
Number on Dips Table	Depth (feet)	Azimuth (degrees)	Strike (degrees)	Dip (degrees)	Upper Depth (feet)	Lower Depth (feet)	Description
12	53.36	N043	N313	39.8NE	53.156	53.564	Wide Open Fracture Discontinuous
11	54.361	N084	N354	32.6E	54.203	54.519	Partial Open Fracture
10	58.225	N071	N341	25.3NE	58.104	58.345	Partial Open Fracture
9	60.008	N037	N307	12.8NE	59.954	60.062	Continuous Open Fracture(s)
8	65.368	N109	N019	30.7SE	65.222	65.515	Partial Open Fracture
7	67.607	N042	N312	40.7NE	67.396	67.819	Partial Open Fracture
6	72.949	N274	N184	54.7W	72.592	73.306	Partial Open Fracture
5	73.558	N094	N004	44.4E	73.311	73.804	Partial Open Fracture
4	74.383	N274	N184	58.1W	73.984	74.782	Partial Open Fracture Possible
3	79.835	N281	N191	47.4W	79.559	80.111	Partial Open Fracture Possible
2	80.73	N270	N180	56.9W	80.335	81.124	Partial Open Fracture Possible
1	85.533	N276	N186	49.9W	85.236	85.829	Sealed Feature

Appendix B
Well 1IW04 Acoustic Televiewer Description
Solvent Pit Area Pilot Study Work Plan
Site 1, Allegany Ballistics Laboratory

Zone: 29.9 - 89.2 below ground surface							
Number on Dips Table	Depth (feet)	Azimuth (degrees)	Strike (degrees)	Dip (degrees)	Upper Depth (feet)	Lower Depth (feet)	Description
9	39.882	N323	N233	22.6N	39.78	39.984	Continuous Open Fracture
8	42.163	N336	N246	11.2N	42.116	42.21	Partial Open Fracture
7	62.76	N080	N350	32.2E	62.608	62.912	Partial Open Fracture Possible
6	66.473	N083	N353	21.3E	66.378	66.568	Partial Open Fracture Possible
5	68.571	N102	N012	46.7E	68.658	68.826	Partial Open Fracture Possible
4	74.581	N083	N353	34.7E	74.406	74.756	Wide Open Fracture
3	76.688	N275	N185	53.6W	76.348	77.028	Partial Open Fracture Possible
2	83.47	N093	N003	51.0E	83.148	83.792	Continuous Open Fracture
1	86.66	N270	N180	57.8W	86.278	87.043	Partial Open Fracture Possible

Appendix B
Well 1MW02 Optical Televiewer Description
Solvent Pit Area Pilot Study Work Plan
Site 1, Allegany Ballistics Laboratory

Zone: 26.184 - 89.248 below ground surface							
Number on Dips Table	Depth (feet)	Azimuth (degrees)	Strike (degrees)	Dip (degrees)	Upper Depth (feet)	Lower Depth (feet)	Description
18	37.845	N117	N027	81.3SE	36.581	39.108	0 - Sealed feature
17	39.582	N075	N345	4.4NE	39.575	39.59	1 - Partial Open Fracture
16	42.783	N110	N020	63.0SE	42.333	43.234	1 - Partial Open Fracture
15	43.43	N136	N046	31.9SE	43.28	43.58	2 - Continuous Open Fracture
14	47.761	N117	N027	62.3SE	47.333	48.189	1 - Partial Open Fracture Possible
13	54.022	N116	N026	80.3SE	52.881	55.163	1 - Partial Open Fracture
12	56.723	N278	N188	62.9W	56.135	57.31	1 - Partial Open Fracture
11	57.058	N099	N009	65.4E	56.599	57.517	1 - Partial Open Fracture
10	57.787	N284	N194	56.1W	57.374	58.2	1 - Partial Open Fracture
9	60.56	N103	N013	74.9E	59.838	61.283	0 - Sealed feature
8	61.637	N273	N183	10.9W	61.58	61.694	1 - Partial Open Fracture
7	65.181	N105	N015	83.4E	63.836	66.525	0 - Sealed feature
6	65.827	N104	N014	84.7E	64.29	67.364	0 - Sealed feature
5	68.347	N267	N177	45.6W	68.057	68.637	0 - Sealed feature
4	75.666	N100	N010	67.4E	75.148	76.184	1 - Partial Open Fracture
3	80.193	N318	N228	67.0NW	79.632	80.755	0 - Sealed feature
2	85.559	N101	N011	59.1E	85.22	85.899	1 - Partial Open Fracture
1	86.042	N108	N018	57.8SE	85.698	86.385	1 - Partial Open Fracture

Appendix B
Well 1MW03 Optical Televiewer Description
Solvent Pit Area Pilot Study Work Plan
Site 1, Allegany Ballistics Laboratory

Zone: 25.3 - 87.4 below ground surface							
Number on Dips Table	Depth (feet)	Azimuth (degrees)	Strike (degrees)	Dip (degrees)	Upper Depth (feet)	Lower Depth (feet)	Description
24	39.49	N101	N011	78.3E	37.94	41.041	0 - Sealed feature Possible
23	41.477	N100	N010	85.5E	38.894	44.061	1 - Partial Open Fracture Possible
22	45.819	N107	N017	69.5S	45.131	46.508	0 - Sealed feature
21	47.562	N101	N011	75.4E	46.627	48.496	0 - Sealed feature
20	53.386	N041	N311	34.6N	53.206	53.566	3 - Wide Open Fracture(s)
19	54.248	N082	N352	35.6E	54.064	54.432	1 - Partial Open Fracture
18	58.115	N046	N316	28.0N	57.978	58.253	1 - Partial Open Fracture
17	59.883	N036	N306	15.1N	59.81	59.956	2 - Continuous Open Fracture
16	61.017	N263	N173	25.1W	60.902	61.133	1 - Partial Open Fracture
15	62.612	N018	N288	15.3N	62.53	62.694	1 - Partial Open Fracture
14	65.257	N092	N002	25.6E	65.133	65.381	1 - Partial Open Fracture Possible
13	66.545	N266	N176	65.1W	66	67.09	1 - Partial Open Fracture Possible
12	66.915	N298	N208	46.6N	66.643	67.186	1 - Partial Open Fracture
11	67.326	N064	N334	54.2N	66.976	67.677	1 - Partial Open Fracture
10	69.588	N261	N171	67.0W	69.018	70.158	0 - Sealed feature
9	72.859	N275	N185	54.6W	72.525	73.193	1 - Partial Open Fracture
8	73.415	N075	N345	43.4N	73.173	73.658	1 - Partial Open Fracture
7	74.355	N255	N165	60.8S	73.894	74.817	1 - Partial Open Fracture Possible
6	75.598	N258	N168	56.6W	75.231	75.966	0 - Sealed feature
5	78.383	N255	N165	56.6S	77.993	78.773	1 - Partial Open Fracture Possible
4	79.661	N270	N180	51.8W	79.352	79.969	1 - Partial Open Fracture Possible
3	81.184	N267	N177	43.8W	80.935	81.432	0 - Sealed feature
2	82.749	N256	N166	51.6W	82.453	83.046	1 - Partial Open Fracture Possible
1	85.444	N266	N176	47.1W	85.183	85.704	0 - Sealed feature

Appendix B
Well 1IW04 Acoustic Televiewer Description
Solvent Pit Area Pilot Study Work Plan
Site 1, Allegany Ballistics Laboratory

Zone: 25.4 - 89.5 below ground surface							
Number on Dips Table	Depth (feet)	Azimuth (degrees)	Strike (degrees)	Dip (degrees)	Upper Depth (feet)	Lower Depth (feet)	Description
20	39.776	N307	N217	29.8NW	39.636	39.916	2 - Continuous Open Fracture
19	42.076	N328	N238	22.5NW	41.97	42.183	1 - Partial Open Fracture
18	47.805	N109	N019	79.1SE	46.702	48.907	0 - Sealed feature
17	56.993	N012	N282	7.9N	56.952	57.034	1 - Partial Open Fracture Possible
16	57.596	N307	N217	20.9NW	57.49	57.701	1 - Partial Open Fracture Possible
15	62.656	N060	N330	32.6NE	62.499	62.812	1 - Partial Open Fracture Possible
14	65.685	N264	N174	62.3W	65.228	66.143	0 - Sealed feature
13	66.37	N093	N003	26.9E	66.239	66.5	1 - Partial Open Fracture Possible
12	68.379	N077	N347	51.2E	68.449	68.551	1 - Partial Open Fracture Possible
11	68.895	N348	N258	43.7N	68.64	69.15	0 - Sealed feature
10	70.159	N266	N176	56.2W	69.786	70.533	0 - Sealed feature
9	73.603	N254	N164	52.8SW	73.273	73.934	0 - Sealed feature
8	74.418	N064	N334	36.6NE	74.22	74.615	3 - Wide Open Fracture(s)
7	77.837	N268	N178	53.3W	77.516	78.158	1 - Partial Open Fracture Possible
6	79.73	N268	N178	53.1W	79.404	80.056	1 - Partial Open Fracture Possible
5	81.218	N261	N171	45.3W	80.967	81.469	0 - Sealed feature
4	83.328	N075	N345	47.2NE	83.032	83.623	1 - Partial Open Fracture
3	83.783	N259	N169	54.6W	83.457	84.108	1 - Partial Open Fracture
2	84.668	N255	N165	52.3SW	84.36	84.976	1 - Partial Open Fracture
1	86.461	N261	N171	61.4W	86.049	86.874	1 - Partial Open Fracture

Appendix C
Field Sampling Plan (FSP) Addendum

APPENDIX C

Field Sampling Plan (FSP) Addendum

This appendix describes the additions or changes to the FSP contained in the Phase II and Phase III SWMU/AOC Investigation Work Plans. The changes contained herein supercede all other documentation.

Field activities proposed in this Work Plan include:

- Alluvial monitoring well installation,
- Bedrock monitoring well installation,
- Well Development
- Surveying
- Alluvial and bedrock well groundwater sampling
- Sodium persulfate and potassium permanganate injection

The field activities listed above will be conducted in accordance with the general CH2M HILL Standard Operation Procedures (SOPs) previously provided in the Phase II and Phase III SWMU/AOC Investigation Work Plans (CH2M HILL, 2000 and 2002a). SOPs for those activities included in this Work Plan Addendum but not included in the previous Phase II and Phase III SWMU/AOC Investigation Work Plans are included in this appendix. Specific requirements for well construction contained in this FSP Addendum supersede the information in the SOPs.

Field Investigation Procedures

A summary of field investigation procedures for field activities not previously described in the Phase III SWMU/AOC Work Plan (CH2M HILL, 2002a) is provided below.

Alluvial Well Installation

Monitoring and injection wells in the alluvial aquifer will be installed using casing advancement, following the SOP of the Phase II SWMU/AOC. However, the riser and screen installed in the injection wells will be made of stainless steel. The well will be used to inject the oxidant sodium persulfate, followed by steam which functions as the heat catalyst to activate the sodium persulfate. Therefore stainless steel screen and risers will be used.

The monitoring well will have a 2- to 3-foot riser extending above the ground surface. The 6 injection wells will have a 6-inch riser extending above the ground surface. A Morie Grade No. 0 or 00N sand filter pack will be installed in the annular space between the borehole wall and the screen to an elevation approximately 5 feet above the top of the screen. A minimum 5-foot-thick, bentonite seal will be added to the top of the sand filter pack, followed by a bentonite slurry grout to approximately 1-foot below the ground surface.

All wells will be finalized using a 6-inch inner diameter outer protective steel casing equipped with a locking cap, installed around the wells and extending at least 3 feet below

ground surface and 2 feet above ground. In addition, a 4-foot by 4-foot by 1-foot concrete pad with 4 embedded steel bollards shall be constructed around each well. Well development of all monitoring wells will include: removing water from the well using a submersible pump capable of flow rates from 0.5 to 2 gallons per minute; and transferring development water to the Water Treatment Plant.

Sodium Persulfate and Potassium Permanganate Injection

Sodium persulfate with steam as a catalyst will be injected into the alluvial injection wells and potassium permanganate will be injected in the bedrock wells. Total volume of injectate will be approximately 10% of the estimated pore volume in the target zone. Injection pressure will be between 20 and 100 psi and a flow rate of between 2 and 6 gpm using an air powered diaphragm pump. Injection rates and pressures will be noted during injection. All wells in the zone of influence will be sealed during injection and the grounds will be monitored to ensure no surface leaks occur.

Installation of Bedrock Monitoring Wells

I. Purpose and Scope

The purpose of this procedure is to outline equipment and methods that will be used for bedrock well installation and development.

II. Equipment and Materials

Drilling

- Drilling Rig (casing advancement or air-rotary or air-hammer)

Surface casing

- 6-inch to 12-inch ID steel
- Temporary bottom plug
- Bentonite for grout: pure, additive-free powdered bentonite
- Cement-Bentonite Grout. Proportion 6 to 8 gallons of water per 94-pound bag of Portland cement; 3 to 10 pounds of bentonite added per bag of cement to reduce shrinkage.

Well Installation

- Wells will remain as open boreholes.

Development

- Double surge block with bottom solid, top open, separated by 2 feet of slotted pipe for well development
- Pump and associated development equipment
- Calibrated meters to ensure pH, temperature, specific conductance, Eh, and dissolved oxygen of development water
- Containerization for water produced from well

III. Procedures and Guidelines

A. Drilling Methods

Boreholes for the bedrock monitoring wells will be drilled in several stages.

1. Casing Advancement Drilling

Casing advancement drilling technology is useful where unconsolidated or poorly consolidated materials are present. Casing advancement drilling uses a temporary outer steel casing that acts as a restraining wall to prevent formation collapses into boreholes during surface and well casing installation. A temporary outer casing is advanced with the drill bit during the borehole installation. Casing advancement drilling may be used to install surface isolation casing.

Casing advancement drilling prevents the collection of soil samples for lithologic characterization.

Drill rods and core barrel with a minimum 6-inch inside diameter (ID) will be used to drill monitoring well boreholes. The temporary outer casing will be advanced with the drill bit during the drilling of boreholes.

The use of water and drilling fluid to assist in drilling for monitoring well installation will be avoided, unless required for such conditions as running sands/gravel or drilling bedrock formations.

Temporary outer casing, drill rods, core barrels, and other downhole drilling tools will be properly decontaminated prior to the initiation of drilling activities and between each borehole location. SOP *Decontamination of Drilling Rigs and Equipment* details proper decontamination procedures.

Drill cuttings and decontamination fluids generated during well drilling activities will be contained according to the procedures detailed in the Field Sampling Plan.

2. Air Rotary or Air Hammer Drilling

Air-rotary or air-hammer drilling techniques will be used to install wells in each of the bedrock monitoring boreholes. When the borehole is advanced beyond the 6-inch surface casing, the borehole will have a diameter of 5-7/8 inches.

The bit, drill rods, and other borehole rotary drilling equipment will be decontaminated prior to the initiation of drilling and between each borehole location, in accordance with the decontamination procedures detailed in SOP *Decontamination of Drilling Rigs and Equipment*.

Drill cuttings and decontamination fluids generated during rotary drilling activities will be contained according to the procedures detailed in SOP *Disposal of Waste Fluids and Solids* and the Investigation Derived Waste Management Plan (IDWMP).

B. Surface Casing Installation

Surface casing will be constructed of a minimum 6-inch ID steel or with a minimum wall thickness of 0.20 inches. Casing lengths will be welded or connected by threaded connections sealed with Teflon tape. The steel casing and threaded couplings must be free of paint, varnish, or coatings of any kind, both inside and outside. Threaded connections must be free of oils or grease. Welding of the casing is permissible provided that the welds meet the Standards of the American Welding Society.

Surface casing will be decontaminated prior to installation in accordance with the procedures detailed in SOP *Decontamination of Drilling Rigs and Equipment*.

Permanent surface casing will be placed in the bottom of the borehole. The surface casing will be grouted in place by installing the grout through a tremie pipe from the bottom of the annulus to the ground surface.

Alternatively, the surface casing will be installed and grouted in place by a grout displacement method. The bottom of the surface casing is fitted with a tight, drillable plug. The borehole is then filled with the estimated volume of cement-bentonite grout to fill the annular space, and the casing is lowered to the bottom of the borehole (displacement method). If the weight of the casing is not sufficient to displace the grout and allow the casing to sink to the bottom of the borehole, the casing may be filled with clean water.

After the surface casing installation, the grout will be allowed to set up for at least 16-24 hours before drilling proceeds. Once the surface casing is installed, all water in the casing will be removed and disposed of according to SOP *Disposal of Waste Fluids and Solids* and the IDWMP before drilling is resumed. All water in the surface casing will be removed before drilling resumes in order to prevent carrying contamination downward into deeper intervals of the water-bearing unit.

C. Monitoring-Well Completion

For monitoring wells that will be completed above-grade, the surface casing itself will serve as the protective casing. The surface casing will be finished 2 to 3 feet above grade and fitted with a locking steel cap. A concrete pad with four guard posts will be installed.

The concrete pad will be square, approximately 3 feet per side, and poured into wooden forms. The concrete will be sloped away from the protective casing. The concrete pad will extend at least 6 inches below and 6 inches above the ground surface.

Four steel guard posts will be installed around the locking casing. Guard posts would be concrete-filled, at least 2 inches in diameter, and would extend at least 2 feet into the ground and 3 feet above the ground. The protective casing and guard posts will be painted bright orange with an epoxy paint to prevent rust.

For monitoring wells with flush-mount completions, a Morrison 519 manhole cover with a rubber-sealed cover and drain will be installed. The top of the manhole will be positioned approximately 1 inch above grade. A square concrete pad, approximately 3 feet per side, will be installed as a concrete collar surrounding the road box cover, and will slope uniformly downward to the adjacent grade. The road box and installation thereof will be of sufficient strength to withstand normal vehicular traffic. The concrete pad will extend at least 12 inches below the ground surface.

Inside the manhole, a locking cap will be placed over the permanent casing.

Each well will be labeled on the exterior of the locking cap with a metal stamp indicating the permanent well number. The well identification will be painted using stencils in black lettering on the well's protective casing.

D. Well Development

Well development will be accomplished using a combination of surging throughout the well screen and pumping, until the physical and chemical parameters of the discharge water that are measured in the field have stabilized and the turbidity of the discharge water is substantially reduced. Fine-grained materials in the surficial aquifer at the site may not allow low turbidity results to be achieved.

The surging apparatus will include two surge blocks separated by approximately 2 feet of coarsely slotted pipe. The lower surge block will be solid; the upper surge block will be open and attached to riser pipe leading to the ground surface. Water will be pumped continuously from the surge block screened interval throughout the surging process. The pumping will be accomplished by airlift induction methods or using a centrifugal pump or equivalent.

Well development will begin by surging the well screen, starting at the bottom of the screen and proceeding upwards, throughout the screened zone. This method is not required for wells constructed with open boreholes.

Following surging, the well will be pumped to remove the fine materials that have been drawn into the well. During pumping, measurements of pH, temperature, and specific conductance will be recorded.

Development will continue by alternately surging and pumping until the discharge water is free from sand and silt, the turbidity is substantially reduced, and the pH, temperature, and specific conductance have stabilized at regional background levels, based on historical data. Development will continue for a minimum of 30 minutes and until the water removed from the well is as clear of turbidity as practicable.

Well development equipment will be decontaminated prior to initial use and after the development of each well. Decontamination procedures are detailed in *SOP Decontamination of Personnel and Equipment*. Water generated during well development will be contained and managed as detailed in the *SOP Disposal of Waste Fluids and Solids* and the IDWMP.

Appendix D
Quality Assurance Project Plan (QAPP)
Addendum

APPENDIX D

Quality Assurance Project Plan Addendum

This appendix describes the additions or changes to the QAPP in the Phase III SWMU/AOC Investigation Work Plan (CH2M HILL, 2002a). The changes contained herein supercede all other documentation.

Analyses proposed in this characterization Work Plan, not previously listed in the above mentioned QAPP, include:

- 1,4 Dioxane
- TAL metals (total)
- Chromium
- Nickel
- Manganese
- Sulfate
- TOC
- Alkalinity

The analyses proposed for each sample at Site 1 are presented in Table 6 of the work plan. The lab will be notified to include the 1,4 Dioxane with the CLPOLM04.2 TCL VOC list using method SW846 8260B and utilizing CLP reporting limits and QC criteria. Table 2 of the Final Work Plan for the Characterization Phase of Pilot Studies (CH2M HILL, 2004) lists analytical methods, containers, preservatives, and holding times for the proposed analysis presented in this work plan addendum. Table 1 in this addendum list the analytical methods, precision, and accuracy for the analyses proposed.

Quality assurance/quality control samples will be collected at the same frequency as during the previous SWMU/AOC investigations. Section 10 of the Phase II SWMU/AOC Investigation Work Plan (CH2M HILL, 2000) summarizes the frequency for collecting QA/QC samples.

TABLE 1
Precision, Accuracy, and Completeness Objectives
Solvent Pit Area Pilot Study Work Plan
Allegany Ballistics Laboratory, Rocket Center, West Virginia

Parameter	Precision (Relative Percent Difference)	Accuracy (% Spike Recovery)	Intended Data Use
Water			
TCL VOCs plus 1,4 Dioxane	< ±20	80-120	Monitor contaminate removal
TAL Total Metals	< ±20	80-120	Monitor metals leaching
Chromium	< ±20	80-120	Monitor effects of oxidation
Manganese	< ±20	80-120	Monitor effects of oxidation
Nickel	< ±20	80-120	Monitor effects of oxidation
Sulfate	< ±25	75-125	Monitor potential biofouling in the WTP
TOC	< ±25	75-125	Monitor contaminate removal
Alkalinity	< ±25	75-125	Monitor contaminate removal

Notes: TCL = Target Compound List; TAL = Target Analyte List; TOC = total organic carbon;

Appendix E

Health and Safety Plan (HASP) Addendum

APPENDIX E

Health and Safety Plan (HASP) Addendum

The Master HASP for the Allegany Ballistics Laboratory Restoration Program and this HASP addendum will be used to complete the work described in the Work Plan for the Characterization of Pilot Studies at the Solvent Disposal Pit Area of Site 1, dated April 2005.

Amendment CH2M HILL Health and Safety Plan

This amendment must accompany the Master Health and Safety Plan (HASP) for the Allegany Ballistics Laboratory Installation Restoration Program for the Allegany Ballistics Laboratory, Rocket Center, West Virginia approved in December 2005. The purpose of the HASP amendment is to include supplemental information, as it becomes available. Supplemental information is used to reevaluate hazards associated with the planned tasks and to revise protective procedures (e.g., air monitoring). Where the amendment contains information different from the HASP, the amendment will take precedence for the specified task. The amendment includes new information or revises existing HASP information. Sections of the HASP that are not addressed in the amendments do not have changes; therefore, the HASP will be followed. All employees performing tasks covered by this amendment must read both the HASP and this amendment and agree to abide by their provisions (see Attachment 1).

PROJECT INFORMATION AND DESCRIPTION

CLIENT OR OWNER: Naval Facilities Engineering Command,

PROJECT NO: 157976.PP.WP

PROJECT MANAGER: Steve Glennie

OFFICE: WDC

TASK MANAGER: Jose Amaya

OFFICE: WDC

SITE NAME: Allegany Ballistics Laboratory

SITE ADDRESS: Rocket Center, West Virginia

DATE AMENDMENT PREPARED: 04/15/2005

DATE(S) OF SITE WORK: April 2005 through December 2005

Hazwoper-Regulated Tasks

- Drilling
- Well Installation
- Groundwater Sampling
- Well injection of sodium persulfate
- Well injection of potassium persulfate

Task Hazard Analysis

(Refer to Section 2 for hazard controls)

Tasks	
Potential Hazards	Well Injection
Flying debris/ objects	
Noise > 85dBA	
Electrical	X
Suspended loads	
Buried utilities, drums, tanks	
Slip, trip, fall	X
Back injury	X
Visible lightning	X
Vehicle traffic	
Fires	
Entanglement	
Drilling	
Heavy equipment	X

*** Note: Refer to the Task Hazard Analysis Table (1.2) in the Final Master Health and Safety Plan for the Allegany Ballistics Laboratory Installation Restoration Program (HSP) for information regarding: Drilling, Well Installation, Groundwater Sampling, Surface Water Sampling tasks associated with this field event .**

CH2M HILL Employee Medical Surveillance and Training

(Reference CH2M HILL SOPs HSE-113, *Medical Monitoring*, and HSE-110, *HS&E Training*)

Employee Name	Office	Responsibility	SSC/FA-CPR
Cassandra Brown	WDC	Field Team Member Lead/SSC	Level B SSC; FA-CPR
David Grose	WDC	Field Team Member	Level C SSC; FA-CPR
Jose Amaya	WDC	Task Manager	Level C SSC; FA-CPR
Steve Glennie	WDC	Project Manager	Level C SSC; FA-CPR

CH2M HILL Subcontractors

(Reference CH2M HILL SOP HS-55, *Subcontractor, Contractor, and Owner*)

Subcontractor: **TBD**
 Subcontractor Contact Name: **TBD**
 Telephone: **TBD**

The subcontractors listed above are covered by this HSP and must be provided a copy of this plan. However, this plan does not address hazards associated with the tasks and equipment that the subcontractor has expertise in (e.g., drilling, excavation work, electrical). Subcontractors are responsible for the health and safety procedures specific to their work, and are required to submit these procedures to CH2M HILL for review before the start of field work. Subcontractors must comply with the established health and safety plan(s). The CH2M HILL SSC should verify that subcontractor employee training, medical clearance, and fit test records are current and must monitor and enforce compliance with the established plan(s). CH2M HILL's oversight does not relieve subcontractors of their responsibility for effective implementation and compliance with the established plan(s).

CH2M HILL should continuously endeavor to observe subcontractors' safety performance. This endeavor should be reasonable, and include observing for hazards or unsafe practices that are both readily observable and occur in common work areas. CH2M HILL is not responsible for exhaustive observation for hazards and unsafe practices. In addition to this level of observation, the SSC is responsible for confirming CH2M HILL subcontractor performance against both the subcontractor's safety plan and applicable self-assessment checklists. Self-assessment checklists contained in Attachment 6 are to be used by the SSC to review subcontractor performance.

Health and safety related communications with CH2M HILL subcontractors should be conducted as follows:

- Brief subcontractors on the provisions of this plan, and require them to sign the Employee Signoff Form included in Attachment 1.
- Request subcontractor(s) to brief the project team on the hazards and precautions related to their work.

- When apparent non-compliance/unsafe conditions or practices are observed, notify the subcontractor safety representative and require corrective action – the subcontractor is responsible for determining and implementing necessary controls and corrective actions.
- When repeat non-compliance/unsafe conditions are observed, notify the subcontractor safety representative and stop affected work until adequate corrective measures are implemented.
- When an apparent imminent danger exists, immediately remove all affected CH2M HILL employees and subcontractors, notify subcontractor safety representative, and stop affected work until adequate corrective measures are implemented. Notify the Project Manager and HSM as appropriate.
- Document all oral health and safety related communications in project field logbook, daily reports, or other records.

Personal Protective Equipment (PPE)

(Reference CH2M HILL SOP HS-07, *Personal Protective Equipment*, HS-08, *Respiratory Protection*)

PPE Specifications ^a

Task	Level	Body	Head	Respirator ^b
<ul style="list-style-type: none"> General site uniform when no chemical exposure is anticipated. 	D	Work clothes; steel-toe, leather work boots; work glove.	Hardhat ^c Safety glasses Ear protection ^d	None required
<ul style="list-style-type: none"> Geoprobe boring Surface Water Sampling GW treatment operations 	D	Boots: Steel-toe leather work boots Gloves: Inner surgical-style nitrile &/or outer chemical-resistant nitrile gloves.	Hardhat ^c Splash shield ^c Safety glasses Ear protection ^d	None required.
<ul style="list-style-type: none"> Conventional drilling Well installation Groundwater Sampling Tasks requiring additional chemical protective clothing 	Modified D	Coveralls: Uncoated Tyvek® Boots: Steel-toe, chemical-resistant boots OR steel-toe, leather work boots with outer rubber boot covers Gloves: Inner surgical-style nitrile & outer chemical-resistant nitrile gloves.	Hardhat ^c Splash shield ^c Safety glasses Ear protection ^d	None required.
<ul style="list-style-type: none"> Tasks requiring upgrade per Section 5.1 or 6. 	C	Coveralls: Polycoated Tyvek® Boots: Steel-toe, chemical-resistant boots OR steel-toe, leather work boots with outer rubber boot covers Gloves: Inner surgical-style nitrile & outer chemical-resistant nitrile gloves.	Hardhat ^c Splash shield ^c Ear protection ^d Spectacle inserts	APR, full face, MSA Ultratwin or equivalent; with GME-H cartridges or equivalent ^e .

Reasons for Upgrading or Downgrading Level of Protection

Upgrade ^f	Downgrade
<ul style="list-style-type: none"> Request from individual performing tasks. Change in work tasks that will increase contact or potential contact with hazardous materials. Occurrence or likely occurrence of gas or vapor emission. Known or suspected presence of dermal hazards. Instrument action levels (Section 5) exceeded. 	<ul style="list-style-type: none"> New information indicating that situation is less hazardous than originally thought. Change in site conditions that decreases the hazard. Change in work task that will reduce contact with hazardous materials.

^a Modifications are as indicated. CH2M HILL will provide PPE only to CH2M HILL employees.

^b No facial hair that would interfere with respirator fit is permitted.

^c Hardhat and splash-shield areas are to be determined by the SSC.

^d Ear protection should be worn when conversations cannot be held at distances of 3 feet or less without shouting.

^e Cartridge change-out schedule is at least every 8 hours (or one work day), except if relative humidity is > 85%, or if organic vapor measurements are > midpoint of Level C range (refer to Section 5)--then at least every 4 hours. If encountered conditions are different than those anticipated in this HASP, contact the HSM.

^f Performing a task that requires an upgrade to a higher level of protection (e.g., Level D to Level C) is permitted only when the PPE requirements have been approved by the HSM, and an SSC qualified at that level is present.

Air Monitoring/Sampling

(Reference CH2M HILL SOP HS-06, *Air Monitoring*)

Air Monitoring Specifications

Instrument	Tasks	Action Levels ^a		Frequency ^b	Calibration
PID: OVM with 10.6eV lamp or equivalent	Groundwater sampling	0-25 ppm→	Level D	Initially and periodically during task	Daily
		25-100 ppm→	Level C		
Dust Monitor: Visual	Soil Boring (Drilling) & Well installation.	If No Dust Visible. →	Level D	Initially and periodically during tasks	NA
		Visible Dust→	Utilize Engineering Controls (i.e. watering down means).		

^a Action levels apply to sustained breathing-zone measurements above background.

^b The exact frequency of monitoring depends on field conditions and is to be determined by the SSC; generally, every 5 to 15 minutes if acceptable; more frequently may be appropriate. Monitoring results should be recorded. Documentation should include instrument and calibration information, time, measurement results, personnel monitored, and place/location where measurement is taken (e.g., "Breathing Zone/MW-3", "at surface/SB-2", etc.).

10 APPROVAL

This site safety plan has been written for use by CH2M HILL only. CH2M HILL claims no responsibility for its use by others unless specified and defined in project or contract documents. The plan is written for the specific site conditions, purposes, dates, and personnel specified and must be amended if those conditions change.

11 AMENDMENTS

CHANGES MADE BY: Cassandra Brown/WDC

DATE: 04/21/05

CHANGES TO PLAN:

- Addition of Well Injection Tasks (Section 1.1.2)
 - Task Hazard Analysis performed for new tasks. (Section 1.2)
 - Revised Personnel (Section 3)
 - Added New Subcontractor (Section 3.2.3)
 - Revised PPE Schedule (Section 4)
 - Revised Air Monitoring Requirements (Section 5)
 - Added Employee Signoff Form (Attachment 1)
 - Added New MSDS- Sodium Persulfate and Potassium Permanganate (Attachment 6)
 - Updated "Change Management Form" (Attachment 7)
-

AMENDMENT APPROVED BY: Mark W. Simpson

DATE: April 22, 2005



15 DISTRIBUTION

Name	Office	Responsibility	Number of Copies
Lynn Bong	MKE	Safety Program Assistant	1
Steve Beck	MKE	Health and Safety Manager/ Approver	1
Steve Glennie	WDC	Project Manager	1
Jose Amaya	WDC	Task Manager	1
Cassandra Brown	WDC	Field Team Leader, SSC	1
Client		Client Project Manager	

16 ATTACHMENTS

Attachment 1: Employee signoff

Attachment 4: Emergency Contacts Page

Attachment 6: Material Safety Data Sheet

Attachment 7: New Project Task Evaluation Checklist

CH2M HILL HEALTH AND SAFETY PLAN

Attachment 1

EMPLOYEE SIGNOFF

EMPLOYEE SIGNOFF

The employees listed below have been given a copy of this health and safety plan, have read and understood it, and agree to abide by its provisions.

[illegible]

CH2M HILL HEALTH AND SAFETY PLAN

Attachment 4

EMERGENCY CONTACTS PAGE

Emergency Contacts

24-hour CH2M HILL Emergency Beeper – 888/444-1226

Medical Emergency – 911

Facility Medical Response #: 304-726-5310 or 304-726-5136

Call 5400 (using a facility phone)

Local Ambulance #: 304-726-5310 or 304-726-5136

Call 5400 (using a facility phone)

CH2M HILL Medical Consultant

Dr. Jerry Burke

Health Resources

600 West Cummings Park, Suite 3400

Woburn, MA, 01801-4511

800-350-4511

Fire/Spill Emergency – 911

Facility Fire Response #: 304-726-5310 or 304-726-5136

Call 5400 (using a facility phone)

Local Occupational Physician

Corporate Health Center

46440 Benedict Drive, Suite 108

Sterling, VA 20164

703-444-5656

Security & Police – 911

Facility Security #: 304-726-5308

WV State Police #: 304-788-1101

Corporate Director Health and Safety

Name: Dave McCormack/SEA

Phone: 206/453-5005

24-hour emergency beeper: 888-444-1226

Utilities Emergency

Water: Mac Robinson at 304-726-5759

Potomac Edison Electric: 304-263-3700

Health and Safety Manager (HSM)

Name: Steve Beck / MKE

Phone: 414-272-2426

Cell Phone: 414-526-4517

Designated Safety Coordinator (DSC)

Name:

Phone: 703-471-6405

Regional Human Resources Department

Name: Cindy Bauder/WDC

Phone: 703/471-6405 ext. 4243

Project Manager

Name: Steve Glennie/WDC

Phone: 703-471-6405 x4257

Corporate Human Resources Department

Name: Pete Hannon/COR

Phone: 303/771-0900

Federal Express Dangerous Goods Shipping

Phone: 800/238-5355

CH2M HILL Emergency Number for Shipping Dangerous Goods

Phone: 800/255-3924

Worker's Compensation

Contact the Regional Human Resources Department to have an Incident Report Form (IRF) completed. If after hours, contact: Julie Zimmerman at 303/664-3304

Auto Claims

Rental: Carol Dietz/COR
303/713-2757

CH2MHILL owned: Zurich Insurance Co.
1-800-987-3373

Contact the Project Manager. Generally, the Project Manager will contact relevant government agencies.

Facility Alarms: * Wail Sound (alternating frequency) = Plant fire alarm

* Siren (alternating volume) = Emergency alarm. Take cover

* Westminster chimes = All clear

Evacuation Assembly Area(s) and Facility Evacuation Routes: Upon hearing the Plant Fire or Emergency Alarm, exit rooftops, scaffolding, ladders, or similar areas and assemble at the jobsite location. When the fire signal sounds, all motor vehicle movement will immediately cease. Park clear of the right-of-way and remain parked until any emergency response vehicles have passed. All employees must be accounted for in the event of emergency/fire on plant. Employees shall report to the ATK site representative. Remain at the job site during an emergency/fire alarm unless the emergency has impacted your immediate work area at which time exit to building 415 and remain there until the all clear signal is activated.

Hospital

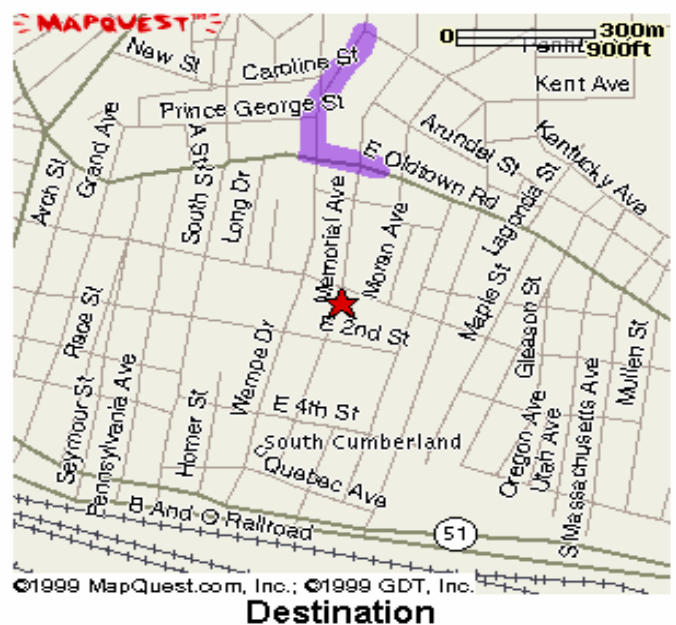
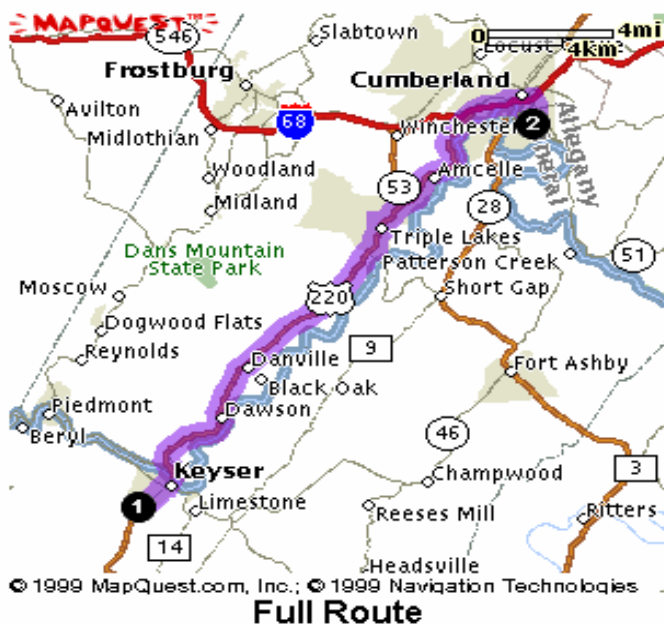
Hospital Name/Address: Memorial Hospital
600 Memorial Ave
Cumberland, MD 21502

Hospital Phone #: 301-723-4000

Directions to Hospital

Directions to Hospital

- WV State Route 956 can no longer be accessed from Site 5. You must first go through the tunnel under State Route 956 back to Site 1.
- From Site 1, turn right (west) on WV State Route 956
- Cross river
- Turn right on US Route 220 and head northeast for approximately 10 miles
- Bear right onto the on-ramp to W. Industrial Blvd (Hwy 51) and head south for 0.5 miles
- Continue on W. Oldtown Rd., heading east for 0.7 miles
- Turn left on Memorial Ave., heading north to 600 Memorial Ave.



CH2M HILL HEALTH AND SAFETY PLAN

Attachment 6

Material Safety Data Sheets

(INSERT Potassium Permanganate and Sodium Persulfate MSDS SHEET HERE)

CH2M HILL HEALTH AND SAFETY PLAN

Attachment 7

New Project Task Evaluation Checklist

New Project Task Evaluation Form

Allegany Ballistics Laboratory Superfund Site

This evaluation form should be completed to determine if the current site health and safety plan adequately addresses the hazards of a new or continued project or task at the ABL Site.

Project Task: Field Investigation of Site 1
Project Number: 157976.PP.WP Project/Task Manager: Jose Amaya
Name: In Situ Chemical Oxidation Pilot Employee #: 34467
Study at the Solvent Disposal Pit
Area of Site 1 Addendum

<i>New Task Evaluation Checklist</i>		Yes	No
1.	Has the CH2MHILL staff listed in the original HASP changed?	X	
2.	Has a new subcontractor been added to the project?	X	
3.	Is any chemical or product to be used that is not listed Attachment 2 of the plan?	X	
4.	Have additional tasks been added to the project which were not originally addressed in Section 1.1 of the plan? (all tasks are listed in Section 1.1.2 but not described in Section 1.1.1)		X
5.	Are the Contaminant data HASP out of date or not applicable to the new task?		X
6.	Are other safety or equipment hazards introduced by the new task that are not addressed in Section 2.1 of the plan?		X

If the answer is "YES" to Questions 1-3, an HASP revision is NOT needed. Please take the following actions:

- ◆ Confirm that staff's medical and training status is current – check training records at <http://www.int.ch2m.com/hands>, or contact Lynn Bong/MKE.
- ◆ Confirm with the project KA that subcontractor safety performance has been reviewed and is acceptable
- ◆ Confirm with H&S that subcontractor safety procedures have been reviewed and are acceptable.

If the answer is "YES" to Questions 4-6, a HASP revision MAY BE NEEDED. To determine if HASP revision is needed please contact H&S directly or complete the field project start-up form at <http://www.int.ch2m.com/hsdocgen/fppricing.asp>

MATERIAL SAFETY DATA SHEET

Sodium Persulfate



MSDS Ref. No.: 7775-27-1

Date Approved: 02/22/2005

Revision No.: 11

This document has been prepared to meet the requirements of the U.S. OSHA Hazard Communication Standard, 29 CFR 1910.1200; the Canada's Workplace Hazardous Materials Information System (WHMIS) and, the EC Directive, 2001/58/EC.

1. PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME:	Sodium Persulfate
SYNONYMS:	Sodium Peroxydisulfate; Disodium Peroxydisulfate
GENERAL USE:	Polymerization initiator. Etchant and cleaner in manufacture of printed circuit boards. Booster in hair bleaching formulations in cosmetics. Secondary oil recovery systems as a polymerization initiator and a gel breaker.

MANUFACTURER

FMC CORPORATION
Active Oxidants Division
1735 Market Street
Philadelphia, PA 19103
(215) 299-6000 (General Information)

EMERGENCY TELEPHONE NUMBERS

(800) 424-9300 (CHEMTREC - U.S.)
(303) 595-9048 (Medical - Call Collect)

2. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW:

- White, odorless, crystals
- Oxidizer.
- Decomposes in storage under conditions of moisture (water/water vapor) and/or excessive heat causing release of oxides of sulfur and oxygen that supports combustion. Decomposition could form a high temperature melt. See Section 10 ("Stability and Reactivity").

POTENTIAL HEALTH EFFECTS: Airborne persulfate dust may be irritating to eyes, nose, lungs, throat and skin upon contact. Exposure to high levels of persulfate dust may cause difficulty in breathing in sensitive persons.

3. COMPOSITION / INFORMATION ON INGREDIENTS

Chemical Name	CAS#	Wt. %	EC No.	EC Class
Sodium Persulfate	7775-27-1	>99	231-892-1	Not classified as hazardous

4. FIRST AID MEASURES

EYES: Flush with plenty of water. Get medical attention if irritation occurs and persists.

SKIN: Wash with plenty of soap and water. Get medical attention if irritation occurs and persists.

INGESTION: Rinse mouth with water. Dilute by giving 1 or 2 glasses of water. Do not induce vomiting. Never give anything by mouth to an unconscious person. See a medical doctor immediately.

INHALATION: Remove to fresh air. If breathing difficulty or discomfort occurs and persists, contact a medical doctor.

NOTES TO MEDICAL DOCTOR: This product has low oral toxicity and is not irritating to the eyes and skin. Flooding of exposed areas with water is suggested, but gastric lavage or emesis induction for ingestions must consider possible aggravation of esophageal injury and the expected absence of system effects. Treatment is controlled removal of exposure followed by symptomatic and supportive care.

5. FIRE FIGHTING MEASURES

EXTINGUISHING MEDIA: Deluge with water.

FIRE / EXPLOSION HAZARDS: Product is non-combustible. On decomposition releases oxygen which may intensify fire. Presence of water accelerates decomposition.

FIRE FIGHTING PROCEDURES: Do not use carbon dioxide or other gas filled fire extinguishers; they will have no effect on decomposing persulfates. Wear full protective clothing and self-contained breathing apparatus.

FLAMMABLE LIMITS: Non-combustible

SENSITIVITY TO IMPACT: No data available

SENSITIVITY TO STATIC DISCHARGE: Not available

6. ACCIDENTAL RELEASE MEASURES

RELEASE NOTES: Spilled material should be collected and put in approved DOT container and isolated for disposal. Isolated material should be monitored for signs of decomposition (fuming/smoking). If spilled material is wet, dissolve with large quantity of water and dispose as a hazardous waste. All disposals should be carried out according to regulatory agencies procedures.

7. HANDLING AND STORAGE

HANDLING: Use adequate ventilation when transferring product from bags or drums. Wear respiratory protection if ventilation is inadequate or not available. Use eye and skin protection. Use clean plastic or stainless steel scoops only.

STORAGE: Store (unopened) in a cool, clean, dry place away from point sources of heat, e.g. radiant heaters or steam pipes. Use first in, first out storage system. Avoid contamination of opened product. In case of fire or decomposition (fuming/smoking) deluge with plenty of water to control decomposition. For storage, refer to NFPA Bulletin 430 on storage of liquid and solid oxidizing materials.

COMMENTS: VENTILATION: Provide mechanical general and/or local exhaust ventilation to prevent release of dust into work environment. Spills should be collected into suitable containers to prevent dispersion into the air.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

EXPOSURE LIMITS

Chemical Name	ACGIH	OSHA	Supplier
Sodium Persulfate	0.1 mg/m ³ (TWA)		

ENGINEERING CONTROLS: Provide mechanical local general room ventilation to prevent release of dust into the work environment. Remove contaminated clothing immediately and wash before reuse.

PERSONAL PROTECTIVE EQUIPMENT

EYES AND FACE: Use cup type chemical goggles. Full face shield may be used.

RESPIRATORY: Use approved dust respirator when airborne dust is expected.

PROTECTIVE CLOTHING: Normal work clothes. Rubber or neoprene footwear.

GLOVES: Rubber or neoprene gloves. Thoroughly wash the outside of gloves with soap and water prior to removal. Inspect regularly for leaks.

9. PHYSICAL AND CHEMICAL PROPERTIES

ODOR:	None
APPEARANCE:	White crystals
AUTOIGNITION TEMPERATURE:	Not applicable. No evidence of combustion up to 800°C. Decomposition will occur upon heating.
BOILING POINT:	Not applicable
COEFFICIENT OF OIL / WATER:	Not applicable
DENSITY / WEIGHT PER VOLUME:	Not available
EVAPORATION RATE:	Not applicable (Butyl Acetate = 1)
FLASH POINT:	Non-combustible
MELTING POINT:	Decomposes
ODOR THRESHOLD:	Not applicable
OXIDIZING PROPERTIES:	Oxidizer
PERCENT VOLATILE:	Not applicable
pH:	typically 5.0 - 7.0 @ 25 °C (1% solution)
SOLUBILITY IN WATER:	73 % @ 25 °C (by wt.)
SPECIFIC GRAVITY:	2.6 (H ₂ O=1)
VAPOR DENSITY:	Not applicable (Air = 1)
VAPOR PRESSURE:	Not applicable

10. STABILITY AND REACTIVITY

CONDITIONS TO AVOID:	Heat, moisture and contamination.
STABILITY:	Stable (becomes unstable in presence of heat, moisture and/or contamination).
POLYMERIZATION:	Will not occur
INCOMPATIBLE MATERIALS:	Acids, alkalis, halides (fluorides, chlorides, bromides and iodides), combustible materials, most metals and heavy metals, oxidizable materials, other oxidizers, reducing agents, cleaners, and organic or carbon containing compounds. Contact

with incompatible materials can result in a material decomposition or other uncontrolled reactions.

HAZARDOUS DECOMPOSITION PRODUCTS: Oxygen that supports combustion and oxides of sulfur.

COMMENTS: PRECAUTIONARY STATEMENT: Use of persulfates in chemical reactions requires appropriate precautions and design considerations for pressure and thermal relief.

Decomposing persulfates will evolve large volumes of gas and/or vapor, can accelerate exponentially with heat generation, and create significant and hazardous pressures if contained and not properly controlled or mitigated.

Use with alcohols in the presence of water has been demonstrated to generate conditions that require rigorous adherence to process safety methods and standards to prevent escalation to an uncontrolled reaction.

11. TOXICOLOGICAL INFORMATION

EYE EFFECTS: Non-irritating (rabbit) [FMC Study Number: ICG/T-79.029]

SKIN EFFECTS: Non-irritating (rabbit) [FMC Study Number: ICG/T-79.029]

DERMAL LD₅₀: > 10 g/kg [FMC Study Number: ICG/T-79.029]

ORAL LD₅₀: 895 mg/kg (rat) [FMC Study Number: ICG/T-79.029]

INHALATION LC₅₀: 5.1 mg/l (rat) [FMC I95-2017]

SENSITIZATION: May be sensitizing to allergic persons. [FMC Study Number: ICG/T-79.029]

TARGET ORGANS: Eyes, skin, respiratory passages

ACUTE EFFECTS FROM OVEREXPOSURE: Dust may be harmful and irritating. May be harmful if swallowed.

CHRONIC EFFECTS FROM OVEREXPOSURE: Sensitive persons may develop dermatitis and asthma [Respiration 38:144, 1979]. Groups of male and female rats were fed 0, 300 or 3000 ppm sodium persulfate in the diet for 13 weeks, followed by 5000 ppm for 5 weeks. Microscopic examination of tissues revealed some injury to the gastrointestinal tract at the high dose (3000 ppm) only. This effect is not unexpected for an oxidizer at high concentrations. [Ref. FMC I90-1151, Toxicologist 1:149, 1981].

CARCINOGENICITY:

NTP:	Not listed
IARC:	Not listed
OSHA:	Not listed
OTHER:	ACGIH: Not listed

12. ECOLOGICAL INFORMATION

ECOTOXICOLOGICAL INFORMATION:

Bluegill sunfish, 96-hour LC_{50} = 771 mg/L [FMC Study I92-1250]
Rainbow trout, 96-hour LC_{50} = 163 mg/L [FMC Study I92-1251]
Daphnia, 48-hour LC_{50} = 133 mg/L [FMC Study I92-1252]
Grass shrimp, 96-hour LC_{50} = 519 mg/L [FMC Study I92-1253]

CHEMICAL FATE INFORMATION: Biodegradability does not apply to inorganic substances.

13. DISPOSAL CONSIDERATIONS

DISPOSAL METHOD: Dispose as a hazardous waste in accordance with local, state and federal regulatory agencies.

14. TRANSPORT INFORMATION

U.S. DEPARTMENT OF TRANSPORTATION (DOT)

PROPER SHIPPING NAME:	Sodium Persulfate
PRIMARY HAZARD CLASS / DIVISION:	5.1 (Oxidizer)
UN/NA NUMBER:	UN 1505
PACKING GROUP:	III
LABEL(S):	5.1 (Oxidizer)
PLACARD(S):	5.1 (Oxidizer)
MARKING(S):	Sodium Persulfate, UN 1505
ADDITIONAL INFORMATION:	Hazardous Substance/RQ: Not applicable

49 STCC Number: 4918733

This material is shipped in 225 lb. fiber drums, 55 lb. poly bags and 1000 - 2200 lb. IBC's (supersacks).

INTERNATIONAL MARITIME DANGEROUS GOODS (IMDG)

PROPER SHIPPING NAME:

Sodium Persulfate

INTERNATIONAL CIVIL AVIATION ORGANIZATION (ICAO) / INTERNATIONAL AIR TRANSPORT ASSOCIATION (IATA)

PROPER SHIPPING NAME:

Sodium Persulfate

OTHER INFORMATION:

Protect from physical damage. Do not store near acids, moisture or heat.

15. REGULATORY INFORMATION

UNITED STATES

SARA TITLE III (SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT)

SECTION 302 EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355, APPENDIX A):

Not applicable

SECTION 311 HAZARD CATEGORIES (40 CFR 370):

Fire Hazard, Immediate (Acute) Health Hazard

SECTION 312 THRESHOLD PLANNING QUANTITY (40 CFR 370):

The Threshold Planning Quantity (TPQ) for this product, if treated as a mixture, is 10,000 lbs; however, this product contains the following ingredients with a TPQ of less than 10,000 lbs.:

None

SECTION 313 REPORTABLE INGREDIENTS (40 CFR 372):

Not listed

CERCLA (COMPREHENSIVE ENVIRONMENTAL RESPONSE COMPENSATION AND LIABILITY ACT)

CERCLA DESIGNATION & REPORTABLE QUANTITIES (RQ) (40 CFR 302.4):

Unlisted, RQ = 100 lbs., Ignitability

TSCA (TOXIC SUBSTANCE CONTROL ACT)

TSCA INVENTORY STATUS (40 CFR 710):

Listed

RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)
RCRA IDENTIFICATION OF HAZARDOUS WASTE (40 CFR 261):
Waste Number: D001

CANADA**WHMIS (WORKPLACE HAZARDOUS MATERIALS INFORMATION SYSTEM):**

Product Identification Number: 1505
Hazard Classification / Division: Class C (Oxidizer), Class D, Div. 2, Subdiv. B. (Toxic)
Ingredient Disclosure List: Listed

INTERNATIONAL LISTINGS

Sodium persulfate:
Australia (AICS): Listed
China: Listed
Japan (ENCS): (1)-1131
Korea: KE-12369
Philippines (PICCS): Listed

HAZARD, RISK AND SAFETY PHRASE DESCRIPTIONS:

EC Symbols: (Not classified as hazardous)
EC Risk Phrases: (Not classified as hazardous)
EC Safety Phrases: (Not classified as hazardous)

16. OTHER INFORMATION

HMIS

Health	1
Flammability	0
Physical Hazard	1
Personal Protection (PPE)	J

Protection = J (Safety goggles, gloves, apron & combination dust & vapor respirator)

HMIS = Hazardous Materials Identification System

Degree of Hazard Code:
4 = Severe

3 = Serious
2 = Moderate
1 = Slight
0 = Minimal

NFPA

Health	1
Flammability	0
Reactivity	1
Special	OX

SPECIAL = OX (Oxidizer)

NFPA = National Fire Protection Association

Degree of Hazard Code:

4 = Extreme
3 = High
2 = Moderate
1 = Slight
0 = Insignificant

REVISION SUMMARY:

This MSDS replaces Revision #10, dated October 05, 2004.

Changes in information are as follows:

Section 1 (Product and Company Identification)

Section 16 (Other Information)

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MATERIAL SAFETY DATA SHEET

CAIROX® Potassium Permanganate

Section 1 Chemical Product and Company Identification

PRODUCT NAME: CAIROX® potassium permanganate, KMnO_4
SYNONYMS: Permanganic acid potassium salt
Chameleon mineral
Condy's crystals
Permanganate of potash

MANUFACTURER'S NAME: CARUS CHEMICAL COMPANY

MANUFACTURER'S ADDRESS:

Carus Chemical Company
1500 Eighth Street
P. O. Box 1500
LaSalle, IL 61301

TRADE NAME: CAIROX® potassium permanganate

TELEPHONE NUMBER FOR INFORMATION: 815/223-1500

EMERGENCY TELEPHONE NO: 800/435-6856

AFTER HOURS NO. 815/223-1565

5:00 PM-8:00 AM Central Standard Time
Monday-Friday, Weekends and Holidays

CHEMTREC TELEPHONE NO.: 800/424-9300

Section 2 Composition/Information on Ingredients

<u>Material or component</u>	<u>CAS No.</u>	<u>%</u>	<u>Hazard Data</u>
Potassium permanganate	7722-64-7	97% min. KMnO_4	PEL-C 5 mg Mn per cubic meter of air
			TLV-TWA 0.2 mg Mn per cubic meter of air

Section 3 Hazards Identification

1. Eye Contact

Potassium permanganate is damaging to eye tissue on contact. It may cause severe burns that result in damage to the eye.

2. Skin Contact

Contact of solutions at room temperature may be irritating to the skin, leaving brown stains. Concentrated solutions at elevated temperature and crystals are damaging to the skin.

3. Inhalation

Acute inhalation toxicity data are not available. However, airborne concentrations of potassium permanganate in the form of dust or mist may cause damage to the respiratory tract.

4. Ingestion

Potassium permanganate, if swallowed, may cause severe burns to mucous membranes of the mouth, throat, esophagus, and stomach.

Section 4 First Aid Measures

1. Eyes

Immediately flush eyes with large amounts of water for at least 15 minutes holding lids apart to ensure flushing of the entire surface. Do not attempt to neutralize chemically. Seek medical attention immediately. Note to physician: Soluble decomposition products are alkaline. Insoluble decomposition product is brown manganese dioxide.

2. Skin

Immediately wash contaminated areas with large amounts of water. Remove contaminated clothing and footwear. Wash clothing and decontaminate footwear before reuse. Seek medical attention immediately if irritation is severe or persistent.

3. Inhalation

Remove person from contaminated area to fresh air. If breathing has stopped, resuscitate and administer oxygen if readily available. Seek medical attention immediately.

4. Ingestion

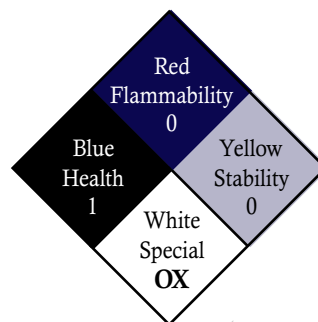
Never give anything by mouth to an unconscious or convulsing person. If person is conscious, give large quantities of water. Seek medical attention immediately.

Section 5 Fire Fighting Measures

NFPA* HAZARD SIGNAL

Health Hazard (less than 1 hour exposure)	1	=	Materials which under fire conditions would give off irritating combustion products. Materials which on the skin could cause irritation.
Flammability Hazard	0	=	Materials that will not burn.
Reactivity Hazard	0	=	Materials which in themselves are normally stable, even under fire exposure conditions, and which are not reactive with water.
Special Hazard	OX	=	Oxidizer

*National Fire Protection Association 704



FIRST RESPONDERS:

Wear protective gloves, boots, goggles, and respirator. In case of fire, wear positive pressure breathing apparatus. Approach site of incident with caution. Use Emergency Response Guide NAERG 96 (RSPA P5800.7). Guide No. 140.

FLASHPOINT

None

FLAMMABLE OR EXPLOSIVE LIMITS

Lower: Nonflammable

Upper: Nonflammable

EXTINGUISHING MEDIA

Use large quantities of water. Water will turn pink to purple if in contact with potassium permanganate. Dike to contain. Do not use dry chemicals, CO₂, Halon® or foams.

SPECIAL FIREFIGHTING PROCEDURES

If material is involved in fire, flood with water. Cool all affected containers with large quantities of water. Apply water from as far a distance as possible. Wear self-contained breathing apparatus and full protective clothing.



CARUS CHEMICAL COMPANY

Section 6 Accidental Release Measures

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED

Clean up spills immediately by sweeping or shoveling up the material. Do not return spilled material to the original container. Transfer to a clean metal drum. EPA banned the land disposal of D001 ignitable waste oxidizers. These wastes must be deactivated by reduction. To clean floors, flush with abundant quantities of water into sewer, if permitted by Federal, State, and Local regulations. If not permitted, collect water and treat chemically (Section 13).

PERSONAL PRECAUTIONS

Personnel should wear protective clothing suitable for the task. Remove all ignition sources and incompatible materials before attempting clean-up.

Section 7 Handling and Storage

WORK/HYGENIC PRACTICES

Wash hands thoroughly with soap and water after handling potassium permanganate, and before eating or smoking. Wear proper protective equipment. Remove contaminated clothing.

VENTILATION REQUIREMENTS

Provide sufficient area or local exhaust to maintain exposure below the TLV-TWA.

CONDITIONS FOR SAFE STORAGE

Store in accordance with NFPA 430 requirements for Class II oxidizers. Protect containers from physical damage. Store in a cool, dry area in closed containers. Segregate from acids, peroxides, formaldehyde, and all combustible, organic or easily oxidizable materials including anti-freeze and hydraulic fluid.

Section 8 Exposure Controls/Personal Protection

RESPIRATORY PROTECTION

In the case where overexposure may exist, the use of an approved NIOSH-MSHA dust respirator or an air supplied respirator is advised. Engineering or administrative controls should be implemented to control dust.

EYE

Faceshield, goggles, or safety glasses with side shields should be worn. Provide eye wash in working area.

GLOVES

Rubber or plastic gloves should be worn.

OTHER PROTECTIVE EQUIPMENT

Normal work clothing covering arms and legs, and rubber or plastic apron should be worn.



CARUS CHEMICAL COMPANY

Section 9 Physical and Chemical Properties

APPEARANCE AND ODOR	Dark purple solid with a metallic luster, odorless
BOILING POINT, 760 mm Hg	Not applicable
VAPOR PRESSURE (mm Hg)	Not applicable
SOLUBILITY IN WATER % BY SOLUTION	6% at 20°C (68°F), and 20% at 65°C (149°F)
PERCENT VOLATILE BY VOLUME	Not volatile
EVAPORATION RATE (BUTYL ACETATE=1)	Not applicable
MELTING POINT	Starts to decompose with evolution of oxygen (O ₂) at temperatures above 150°C (302°F). Once initiated, the decomposition is exothermic and self-sustaining.
OXIDIZING PROPERTIES	Strong oxidizer
SPECIFIC GRAVITY	2.7 @ 20°C (68°F)
VAPOR DENSITY (AIR=1)	Not applicable

Section 10 Stability and Reactivity

STABILITY Under normal conditions, the material is stable.

CONDITIONS TO AVOID Contact with incompatible materials or heat (>150°C/302°F).

INCOMPATIBLE MATERIALS Acids, peroxides, formaldehyde, anti-freeze, hydraulic fluids, and all combustible organic or readily oxidizable inorganic materials including metal powders. With hydrochloric acid, toxic chlorine gas is liberated.

HAZARDOUS DECOMPOSITION PRODUCTS When involved in a fire, potassium permanganate may liberate corrosive fumes.

CONDITIONS CONTRIBUTING TO HAZARDOUS POLYMERIZATION Material is not known to polymerize.

Section 11 Toxicological Information

Potassium permanganate: Acute oral LD₅₀(rat) = 780 mg/kg Male (14 days); 525 mg/kg Female (14 days)
The fatal adult human dose by ingestion is estimated to be 10 grams. (Ref. Handbook of Poisoning: Prevention, Diagnosis & Treatment, Twelfth Edition)

EFFECTS OF OVEREXPOSURE

1. Acute Overexposure
Irritating to body tissue with which it comes into contact.
2. Chronic Overexposure
No known cases of chronic poisoning due to potassium permanganate have been reported. Prolonged exposure, usually over many years, to heavy concentrations of manganese oxides in the form of dust and fumes, may lead to chronic manganese poisoning, chiefly involving the central nervous system.
3. Carcinogenicity
Potassium permanganate has not been classified as a carcinogen by OSHA, NTP, IARC.
4. Medical Conditions Generally Aggravated by Exposure
Potassium permanganate will cause further irritation of tissue, open wounds, burns or mucous membranes.

Registry of Toxic Effects of Chemical Substances
RTECS #SD6476000



CARUS CHEMICAL COMPANY

Section 12 Ecological Information

Entry to the Environment

Potassium Permanganate has a low estimated lifetime in the environment, being readily converted by oxidizable materials to insoluble manganese dioxide (MnO₂).

Bioconcentration Potential

In non-reducing and non-acidic environments manganese dioxide (MnO₂) is insoluble and has a very low bioaccumulative potential.

Aquatic Toxicity

Rainbow trout, 96 hour LC₅₀: 1.8 mg/L
Bluegill sunfish, 96 hour LC₅₀: 2.3 mg/L

Section 13 Disposal Consideration

DEACTIVATION OF D001 IGNITABLE WASTE OXIDIZERS BY CHEMICAL REDUCTION

Reduce potassium permanganate in aqueous solutions with sodium thiosulfate (Hypo), or sodium bisulfite or ferrous salt solution. The thiosulfite or ferrous salt may require some dilute sulfuric acid to promote rapid reduction. If acid was used, neutralize with sodium bicarbonate to neutral pH. Decant or filter, and mix the sludge with sodium carbonate and deposit in an approved landfill. Where permitted, the sludge can be drained into sewer with large quantities of water. Use caution when reacting chemicals. Contact Carus Chemical Company for additional recommendations.

Section 14 Transport Information

U. S. DEPARTMENT OF TRANSPORTATION INFORMATION:

Proper Shipping Name: 49 CFR 172.101 Potassium Permanganate
ID Number: 49 CFR 172.101 UN 1490
Hazard Class: 49 CFR 172.101 Oxidizer
Division: 49 CFR 172.101 5.1
Packing Group: 49 CFR 172.101 II

Section 15 Regulatory Information

TSCA Listed in the TSCA Chemical Substance Inventory

CERCLA **Hazardous Substance**

Reportable Quantity: RQ - 100 lb

40 CFR 116.4; 40 CFR 302.4

RCRA Oxidizers such as potassium permanganate meet the criteria of ignitable waste. 40 CFR 261.21

SARA TITLE III Information

Section 302 Extremely hazardous substance: Not listed

Section 311/312 Hazard categories: Fire, acute and chronic toxicity

Section 313 CAIROX® potassium permanganate contains 97% Manganese Compound as part of the chemical structure (manganese compounds CAS Reg. No. N/A) and is subject to the reporting requirements of Section 313 of Title III, Superfund Amendments and Reauthorization Act of 1986 and 40 CFR 372.

Section 15 Regulatory Information (cont.)

STATE LISTS

Michigan Critical Materials Register:	Not listed
California Proposition 65:	Not listed
Massachusetts Substance List:	5 F8
Pennsylvania Hazard Substance List:	E

FOREIGN LISTS

Canadian Domestic Substances List (DSL)	Listed
Canadian Ingredient Disclosure List	Listed
European Inventory of Existing Chemical Substances (EINECS)	2317603

Section 16 Other Information

NIOSH	National Institute for Occupational Safety and Health
MSHA	Mine Safety and Health Administration
OSHA	Occupational Safety and Health Administration
NTP	National Toxicology Program
IARC	International Agency for Research on Cancer
TSCA	Toxic Substances Control Act
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
RCRA	Resource Conservation and Recovery Act
SARA	Superfund Amendments and Reauthorization Act of 1986
PEL-C	OSHA Permissible Exposure Limit-OSHA Ceiling Exposure Limit
TLV-TWA	Threshold Limit Value - Time Weighted Average (American Conference of Governmental Industrial Hygienists)


Kenneth Krogulski
May 2000


CARUS



The information contained is accurate to the best of our knowledge. However, data, safety standards and government regulations are subject to change; and the conditions of handling, use or misuse of the product are beyond our control. Carus Chemical Company makes no warranty, either express or implied including any warranties of merchantability and fitness for a particular purpose. Carus also disclaims all liability for reliance on the completeness or confirming accuracy of any information included herein. Users should satisfy themselves that they are aware of all current data relevant to their particular uses.

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Responsible Care® is a service mark of the Chemical Manufacturers Association.

Rev. 5/ 00 Form # CX 1028

Appendix F
Investigation Derived Waste Management Plan
(IDWMP) Addendum

APPENDIX F

Investigation-Derived Waste Management Plan (IDWMP) Addendum

This appendix describes the additions or changes to the IDWMP from the Phase II and Phase III SWMU/ AOC Investigation Work Plans (CH2M HILL, 2000 and 2002a). The changes contained herein supercede all other documentation.

The IDW anticipated to be generated during this investigation includes drill cuttings, purge water, decontamination fluids, personal protective equipment (PPE), and sampling equipment.

Prior to mobilization to the site, the subcontractor's equipment will be cleaned. Equipment, tools, and well materials will be decontaminated, as described in the Phase II and Phase III SWMU/ AOC Investigation work plans, prior to each boring and well installation.

IDW composed of drill cuttings, will be containerized prior to sample analysis and waste characterization. Drill cuttings will be sampled by the toxicity characteristic leaching procedure (TCLP) for VOCs, TCLP metals, TCL VOCs, and by the standard techniques for reactivity, corrosivity, and ignitability to characterize the waste. If drill cuttings are non-hazardous, the waste will be disposed offsite at a permitted, non-hazardous landfill. If drill cuttings are hazardous, the waste will be manifested and disposed offsite at a regulated hazardous waste landfill.

Aqueous waste will be contained in a 5,000 gallon Baker tank for transport to the Site 1 groundwater treatment plant. The aqueous waste will be treated at the treatment plant.

All PPE and disposable sampling equipment will be placed in 55-gallon steel drums. Drill cuttings will be placed in a 20 cubic yard rolloff. If drill cuttings are hazardous, PPE drums will be disposed as F-listed hazardous waste. If drill cuttings are disposed as non-hazardous, PPE will be disposed either in a dumpster or as non-hazardous waste.

No additional changes to the IDWMP are noted.